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INSTRUCTION FOR THE ADULT BLIND

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EFFECTIVENESS OF PROGRAMMED LEARNING
IN BRAILLE INSTRUCTION
FOR THE ADULT BLIND

A thesis submitted to the Graduate School of the University of Wisconsin in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

by

George Hanan Stockton

Degree to be awarded

January 19—

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To Professors: Heber

McCarthy

Lambert

This thesis having been approved in respect to form and mechanical execution is referred to you for judgment upon its substantial merit.

Robert Alberty
Dean

Approved as satisfying in substance the doctoral thesis requirement of the University of Wisconsin.

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EFFECTIVENESS OF PROGRAMMED LEARNING IN BRAILLE INSTRUCTION FOR THE ADULT BLIND

BY

GEORGE HANAN STOCKTON

A thesis submitted in partial fulfillment of the requirements for the degree of

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CHAPTER I

INTRODUCTION

The Problem

The manner in which a society cares for its members less fortunate than the majority can, in large measure, determine the true worth of that society. Progress is being made in the fight against social and cultural inequalities, against disease and sickness, and towards the great society; but have long delayed attacking with equal vigor the problems of educating all of its citizens.

An example of this can be seen in the limited progress being made in the teaching of braille to our blind population. Graham (1963) reported that only 3 to 10 per cent of this nation's older blind adults know or use braille, while the number of blind in the United States is estimated to be about .2 per 100 or approximately 385,000. Hurlin (1962) reported about the same number. Census figures show that approximately 65 per cent of our blind population is over 60 years of age and that less than 50 per cent have ever attended a formal

school program specifically providing braille instruction.

Historically, an overview of the significance of the braille tactual system and the role Louis Braille played in its development, is worthy of review.

Louis Braille was born in 1809 and became blind at three years of age. Motivated by an intense will to learn while a pupil at the Paris Institute, he demonstrated considerable interest in Captain Charles Barbier's dot-dash code punched on cardboard. This was used as a means of sending messages to soldiers at night. Barbier's system, however, was too complex and involved too many dots. Louis Braille reduced the number to a total of six forming a "cell" of a size which a finger tip could tactually discriminate with ease.

Nolan, in the 1962 "American Printing House Progress Report," defined <u>braille</u>:

> . . . a raised dot system of writing originally devised by Louis Braille around 1829. Braille characters consist of combinations of dots within a two column, three row cell which result in a total number of sixty-three possible orders that differ from each other by number and position. Braille material in current use today appears in semi-shorthand form in that many words are abbreviated or contracted in some way.

Functionally, braille is often referred to as a tactual communication code. Beginning braillers are usually exposed to the full spelling of each word.

Later they learn the contracted forms which consist of certain cell configurations standing for more than a single letter of the alphabet. Contractions may simply be remembered as abbreviated braille.

The braille system was not accepted in this country until 1860, and its configuration was modified through some violent and bitter controversy during the first decades of this century. The braille cell as we know it today is generally accepted by the majority of educators as a useful method of tactual communication. The use of braille as a tactual alphabet for reading is a fundamental and important skill, essential to successful rehabilitation of blinded adults, and basic to their preparation for ultimate vocational and social adjustment. Yet, few adult blind master this skill.

A person is considered "<u>blind</u>" if, as Lowenfeld (1956), states he has central visual acuity of 20/200 or less in the better eye, with correcting glasses, or central visual acuity of more than 20/200 but with a field defect in which the peripheral field has contracted to such an extent that the widest diameter of visual field subtends an angular distance no greater than 20 degrees. A visual acuity of 20/200 is interpreted to mean that the eye can see at 20 feet what a normal

eye can see at 200 and a deficit in the field of vision refers to the area of sight as being circumvented somewhat less than the normal 60 or 70 degrees. A person meeting this criteria but having some residual vision is generally considered legally blind.

Zahl (1950) reported that home teaching is the principal method used in reaching the adult blind in the United States with a typical teacher pupil ratio of 1-100. This would make it difficult for the average blind adult to receive more than one or two lessons per month. There are others who have been fortunate to receive considerably more training under traditional methods, but still have not acquired adequate braille reading skills.

Because of the obvious limitations imposed by loss of visual acuity, problems of vocational and educational guidance are of particular importance to the blind. Facilitation of the vocational guidance and habilitative processes requires the development of effective and efficient supplementary techniques for the teaching of braille. This is particularly relevant since other aspects of rehabilitation of the blind are highly dependent upon the adequate development of braille as a tool for acquisition of information and communication.

Failure to achieve mastery of this tool reduces the potential for successful social and vocational adjustment.

The development of new ideas and techniques in braille instruction has been hampered by the lack of research in learning and in pedagogical methodology. There appears to be little unanimity of opinion regarding how the blind tactually perceive and associate braille and geometric configurations. The absence of commercial interests in this area is principally due to the limited number of blind in comparison to the general population. This lack of interest has contributed greatly to the limited progress in developing new techniques of braille instruction as a supplement to those practices currently in use.

Another aspect of this problem is the slow rate of communication imposed in the use of braille. Enc and Stolurow (1963), Ashcroft (1962) and Nolan (1962) computed that the average braille reader reads about one third as fast as a sighted reader. This obvious limitation imposes a definite restriction upon the speed at which a blind person can assimilate information. Programming in braille appears to be a logical way of insuring the inclusion of essential information and a reduction of non-essentials.

Furthermore, the aspect of reducing the bulkiness of braille materials and the ever increasing volume of information supports the need for new storage and presentation media. However, progress in this area has been hampered by a lack of research to determine the best means of organizing and presenting braille in order to promote and facilitate optimum learning.

Lowenfeld (1956), Meyerson (1953), Kirk and Weiner (1963), and Ashcroft (1963) have expressed a need for studies encompassing the application of what we already know about braille instruction with a blending of new ideas as they prove feasible and productive. The current techniques for educating the blind are limited principally to the use of a sighted assistant, a talking book, or braille. The Review of Educational Research (1963, p. 40) concurred: "Since Maxfield's (1928) book, no comprehensive treatment of braille reading, writing or methods by which it is taught has been written." In view of the educational gains in other areas, such a need is long overdue.

The Purpose

The purpose of this study is to investigate the effectiveness of programmed learning in braille instruction with adult blind. Programmed materials

and teaching machines were used as supplements to a traditional curriculum of braille instruction in comparison with traditional instruction alone.

The intent was to evaluate specifically: 1. the efficacy of using a self-paced teaching machine for the systematic training of (a) pre-reading tactual discrimination of materials, and (b) braille character discriminations as both relate to the subsequent reading speed; 2. the use of an electronic automated learning device for the tachistoscopic or momentary presentation of braille symbols as reflected in the subsequent speed of braille reading; 3. the use of a machine paced teaching device in accelerating the speed of reading with those who have attained some braille reading ability; and 4. the machine paced method of moving a tape of braille symbols across stationary fingers in contrast with the traditional method of moving fingers across the stationary braille page.

There was no intent to compare one device or program with another. Each had a separate function in a broad approach specifically aimed at increasing braille reading ability.

CHAPTER II

REVIEW OF THE LITERATURE

Braille Reading and Tactual Perception

Early devices of tactual communication were described by Best (1934). Some of these devices were of three dimensional wooden or metal letters, raised or serrated forms of print, alphabet or geometric shapes formed by pins in a cushion or other medium, heavy ink to produce three dimensional writing, and heavy paper strung on threads to form words.

All of these finally led to Barbier's complex "punciform" or "nocturnal writing" and eventually led to the simpler but more efficient braille system.

Examination of the research on tactual perception revealed, just as Nolan (1962) reported, that little factual information exists and even the current perceptual theory is based almost entirely upon data originating in the visual realm. In many cases direct analogies can be drawn between perception of visual

and tactual stimuli, but in other situations this is not possible. Visually or tactually a pen and pencil may be alike or different, but it is more likely that one can detect the smaller differences visually than tactually. Furthermore, tactual perception of an arrow in flight or the color of a flower is a far cry from a visual observation.

Lack of sight restricts a blind person from receiving visually activating stimulation from the outside world. Vision is the first sense by which shape, size, height and width are distinguished, and in its absence, tactual perception is reduced in efficiency. Without vision, an enormous amount of perceivable detail is lacking, and the perception of shape and form cannot proceed in advance of motor development.

A braille reader encounters the characters in a word successively over a short temporal interval. It is assumed he eventaully integrates these successive stimulations through an additive process and arrives at whole word perception. Data supporting these assumptions are as sparse as are data describing the cues that might be used in the process.

Ashcroft (1960) and Schlaegel (1953) found evidence that braille reading involved the same psychological processes as sight reading with the mind perceiving

information through a symbol, comprehending and retaining it. Ashcroft emphasized however, that the biggest problem is one of perceptual span. A sighted person can scan several characters, words or phrases and their meaning and relation to one another. The blind are restricted through tactual perception of individual letters and do not share the scope of cues emanating from the total word form. Ashcroft (1960) also found that contextual cues are not as useful for the blind as for the visually sighted.

Worchel (1951) attempted to evaluate the ability of the blind to perceive tactual form through methods of reproduction, verbal description, and recognition. His procedures isolated form components from all other object components such as weight, texture, and size. He matched 33 blind and 33 sighted S's and exposed them to three tests: 1. a series of simple geometrical blocks presented to one hand of the S; 2. larger blocks with the S's allowed to manipulate them with both hands; and 3. a drawing and description of the blocks were given by the S following the presentation and the method of recognition was utilized by having all blocks be of the same texture but larger than the stimulus block. His results demonstrated that the sighted were significantly better than the blind in reproduction and description;

but when the method of recognition was considered, there were no significant differences between the blind and sighted. His studies demonstrated that the role of visual imagery and a person's ability to translate tactual-kinesthetic impressions into visual imagery permitted better scores on all tests. It appeared, from these studies, that a person blind from birth would be more handicapped than a person having had sight before becoming blind.

Holland (1934) attempted to analyze specific tactual and kinesthetic functions by the observation of braille readers. He used a constant speed camera of 5 frames per second to discover the differences in performance of good and poor braillers and to analyze the reading procedures of individual subjects. He measured reading speed, average number of cells read by right or left hand, time spent at beginning and end of each line, the number of regressive movements, and the time spent by subjects making return sweeps.

He found the performance of poor readers was more variable than that of good readers. Great variability existed in hand preference and finger preference and in coordination of hand movements. Poor readers took more time at the beginning than at the end of lines, while good readers spent more at the end than at the beginning.

Good readers made fewer regressive (retracing) movements than did poor readers and spent less than the total of six to seven per cent of the time the poor readers spent on return sweeps.

He also found fast readers generally used less pressure but that pressure increased slightly at the end of a line. Poor readers demonstrated a greater variance of pressure. Ashcroft (1960) investigated errors in oral reading made by 748 braille reading children. The principal intent of the study was the identification of reading problems. He classified the errors according to type, frequency, and grade level. He identified the principal errors in order of frequency: perceptual problems (missed dots, added dots and ending problems), orientation problems (reversals, vertical alignment and horizontal alignment), and problems of memory (association errors or gross substitutions). He cited this study as an example of descriptive and analytical research which has as its primary purpose the identification of specific problems for future study.

Karp (1962) conducted four experiments in tactual perception using 15 blindfolded M.I.T. students. He was concerned with various physical techniques in learning to identify tactile stimuli. The physical techniques were "place," "stimulus movement" and "free movement." The

results showed free movement the best (subject moves finger as he pleases); movement second (the stimulus moves) and place (stimulus presented directly up-down) last in usefulness for the identification of tactile stimuli.

This research suggested that tactual perception varied as a function of three distinctly different physical movements. Karp found a qualitative significant difference between these presentation techniques, but it remained evident that all were functional. This gave support to the idea that a multiple use of presentation methods might be better than one alone.

Cutsforth (1933) supported the initial presentation of the simpler tactual materials to the blind because they perceive the simpler and symmetrical forms more fully. He stressed the need for a greater difference between training forms for touch for the blind than the sighted need for visual differences and indicated the importance of providing a wide variety of tactual experiences. Jones (1963) also cited the necessity of using a variety of tactual experiences to facilitate tactual perceptual learning.

Horton (1963) went a step further in supporting the idea of a variety of instruction with a systemized handling of the various components such as team teaching,

programmed instruction, teaching machines, and conventional instruction, so that none of them would be overdeveloped while another was neglected.

Restriction of movement in the blind is considered the most serious effect of the handicap. As a result of this, the blind cannot expose themselves to as wide a variety of experiences as their normally sighted peers. This lends support to the above studies which stress the use of a variety of devices and programmed materials to reinforce learning.

The blind need to acquire tactual discrimination of both verbal and graphic forms of communication in the quest of educational and rehabilitative progress. Morris and Nolan (1961) and Foulke (1961) have experimented successfully with tactual patterns to be used as symbols in embossed graphic maps. Morris and Nolan conducted research on areal, linear and point symbols. The number of discriminable tactual symbols possible appeared to be dependent upon the medium in which the symbols are reproduced. The use of virkotype did not prove to be feasible, so the researchers chose to use vacuum formed plastic with 27 different symbols in an investigation of training the blind to learn and retain names for the symbols. Seventy-two and 92 blind subjects were used in two separate but similar studies. It was determined

that fifteen of the 27 symbols were highly discrete and tactually discriminable, and that the use of the vacuum formed plastic media was feasible. Twenty-one subjects were used in another phase of the study that resulted in evidence that they could learn names in association with tactual graphic symbols and retain these associations over a period of time.

Nolan and Morris (1960, 1961) developed a Roughness Discrimination Test for use as a predictor of readiness of children to learn braille which utilized a total of 186 blind boys and girls in kindergarten through grade two. The roughness test was composed of 69 items consisting of four squares of grit paper (18 different gradients) of which one was different. Nolan and Morris (1962) also initiated a study to examine the relationships between the Roughness Discrimination Test (RDT) scores and criteria for braille reading in order to evaluate the validity of the test. Predictive and concurrent validity estimates were predictive either at the .05 or .01 level. All findings indicated that RDT scores obtained were useful in predicting the degree of reading success gained by blind students of this young age.

Another Tactual Discrimination Test (TDT) was developed by Flanigan (1963) and used in a study by

Green (1963). It was concluded that the T.D.T. was valid as an efficient measure of tactual discriminatory improvement which used both verbal and graphic forms.

There has been some research investigating the readability of braille involving varied spacings between dots within cells, between cells, and between lines such as conducted by Meyers and Ethington (1956). Using 108 blind children grades five to 12, it was effectively demonstrated that there was little room for improvement in the dimensions of braille as currently used.

At the turn of the century bitter controversy over the braille configuration finally resulted in the braille system as we know it today. Early in the present century, two studies (Burklen, 1932, and the Uniform Type Committee of the American Association of Workers for the Blind, 1913) investigated the legibility of braille characters. Results were not in close agreement and were based on questionable methodology.

Nolan (Progress Report, 1962) repeated these studies in an investigation using 18 male and 18 female blind, skilled, braille readers attending state schools as subjects. The initial sample was randomly selected from grades 4 through 12. Final selection was determined by the subjects' scores on Grays Standardized Oral Reading Check Test. He used a device called a tachistotactometer,

developed in the Educational Research Department at the American Printing House. He determined threshold values and proceeded with increasing rates for a period of 5 practice sessions. The tachistotactometer is capable of presenting a nine inch line of standard braille by raising it vertically through a thin perforated brass screen at a rate upward from .05 seconds in steps of .01 seconds. The subject sits with his reading finger (s) at a spot on the screen where the braille will appear. His results revealed that differences, significant beyond the .01 level, exist among the recognition thresholds for braille characters. He also found that the mean recognition times of braille characters ranged in seconds from .03 for a one dot configuration progressively to .19 for the six dot combination. It was interesting to note that there was only a slight increase between one dot and two dot combinations of .003 a second. It was also found that, within a given number of dots, some combinations required almost 3 times the recognition time as others formed with a like number of dots.

An absence of empirical data to support the assumption that the blind also read by the whole word method has suggested follow-up studies to explore the significance of this study upon such an assumption.

This research is currently underway at the American Printing House.

Summary Braille Reading and Tactual Perception

Braille will continue to be used as a verbal form of tactual communication because no feasible substitute has evolved after a century of use. Moreover, there is unanimity in support of the present size and height of the cell.

However, upon reviewing the literature little factual information on tactual discrimination was found. It is known that the blind in their dependence on the interoceptive nerves to carry tactual impulses are restricted to a slower rate and span of perception. This is in contradistinction to those with vision who have the exteroceptive sense of sight. Also, those entoptically blinded, after having normal sight, do perceive and involve visual imagery by post visual association. This suggests a relationship between the age of onset, degree of blindness, and the role of visual imagery. Some feel that braille reading involves the same psychological processes as visual reading even though the tactual sense is employed.

There is some evidence that the blind tactually perceive best when the fingers are allowed free

movement, next best when the stimulus moves and least when the stimulus is presented directly in one direction (up-down). All three physical techniques produced tactual learning and will be used in this study.

Upon examining the attempts to identify specific braille reading problems, some agreement is found. Researchers report considerable variability in hand movements between good and poor braille readers. They found fewer regression (retracings), vertical and horizontal movements as well as fewer reading, transfer, omission and addition (substitution) errors in observing the better readers.

There appears to be support for a multiple approach to the teaching of braille and that some graphic forms are more tactually discrete than others. Of particular importance was the medium of presentation. The three dimensional vacuum formed plastic process (Thermoform) has proven successful. The Tactual Discrimination Test, developed for evaluating tactual discrimination of the blind seems to have promise as an assessment device.

There appeared to be a consensus ~~that~~ the tactual sense was a less efficient (speed) and effective (quality) perceptual communicative means than sight. Therefore, it seemed even more essential, in the case of the blind, to maximally develop their tactual sense.

Educational Devices for the Blind

Many of the numerous devices designed to assist in the education of the blind by scanning print and conveying content held great promise of becoming functionally effective. Unfortunately, over a period of years they did not prove to be so.

In 1913 the "Optophone" was designed to scan printed matter by a perforated disc operating upon photocells producing musical sounds corresponding to the characteristics of the letters scanned. Then the Radio Corporation of America perfected a device enabling some readers to read 25 words a minute of simple printed matter. The "Visagraph" in the late 1920's was developed to make an enlarged embossed copy of print material.

Zworykin and Pike (1946) worked on a recognition reading machine that pronounced the name of each letter. It was functionally feasible from an engineering standpoint but proved extremely complex and costly.

Another type of reading machine was in effect an electronic computer which recognized each letter of the alphabet and then selected a recording of that letter sound. One basic restriction of all these devices was their limitation to full spelling or Grade I braille. One recent development reported by Staack (1962) revealed that a machine translation group at the

Massachusetts Institute of Technology has developed a programming language named "COMIT" from their braille contraction studies. This may eventually lead to computer transcription into Grade II (contracted) braille.

Various optical probes, for scanning printed matter, such as those developed by Professor Thomas Benham of Haverford College and Dr. Clifford Witcher of the Massachusetts Institute of Technology in 1955 were never proven practical enough to be functional aids to the blind.

Of the numerous attempts to develop reading machines to scan print and convey the content to the blind, none were sufficiently useful to justify their adoption in competition with the "Talking Book" or "Braille" in spite of the fact that the latter are restricted to specially prepared materials.

International Business Machine Corporation has programmed an I.B.M. 704 Electronic Computer to convert original ink-print text into braille code. With automation such as this in the process of producing reading materials in braille, the increase in number of books available to the blind should at least partially solve the inadequacy of sufficient materials.

While some devices of the present may eventually lead to a point where they are practical, it seems

necessary to presently recognize their worth in experimentation, but to honestly accept the fact that, at this point, few have contributed to improving the methodology of braille instruction. Size and cost are prohibitive factors, but conceivably a functional reading machine (readout device) might eventually be invented to display braille.

A Braille Ad Hoc Committee reported by Staack (1963) represented the American Printing House for the Blind, the Veterans Administration, the Massachusetts Institute of Technology, the International Business Machines, the American Foundation for the Blind and 14 technological researchers who decided that machine translation of braille had reached the production-feasibility stage. They expressed their intent to further implement effective and efficient means of educating the world's blind population. The problem of producing cheap computers appears to be solvable within the next three year period. This would create a need for a suitable output machine, produced at a reasonable cost, that could hopefully display to the blind the world's literature at their fingertips. It is felt that this could conceivably be an endless self-erasing tape.

Ashcroft (1959) conducted a study using an IBM reading device consisting of an endless belt with pins

that were raised or lowered to form braille cells. Information was relayed from an IBM computer serving as a storage device. Nine adult braille readers were given from two to twenty hours practice on the machine. Pre-training reading speeds for conventional braille ranged from 43-165 WPM while post-training speeds for similar material ranged from 81-215 WPM. An indirect finding of this evaluation was that a median increase in reading speeds for conventional braille of about twenty-five per cent resulted.

Nolan (1962) also used the IBM Braille Reader programmed to accept information from IBM equipment. He matched two groups of 15 subjects each by reading grade level representing a cross section of grades nine through 12. His results were successful but restricted due to the mechanical unreliability of the equipment and the limitation of the overall speed of presentation. This intensified an interest in developing a more efficient and effective means of introducing braille.

Bliss (1961) in a study at the Massachusetts Institute of Technology developed an air-driven finger stimulator communication device via the tactile and kinesthetic senses that appeared to have some potential application in the teaching of typing. It moved the fingers horizontally and vertically assimilating all finger movements as are normally made on a regular

typewriter keyboard. This device involved a sequential programming on a punched paper tape. The tape, acting as valves, controlled the flow of air to a complicated system of bellows. These bellows permitted movement of the keys in all directions. Introducing braille in a readout device using a pneumatic presentation method, for the present project, was given serious consideration. However, it was found to be too complex and more costly than other methods under consideration.

Nolan (1962) used a device known as a tachistotactometer that was capable of presenting a single line or cell at a time. He found he could present braille at speeds fast enough for successful diagnostic evaluation of cell perception. However, he did not find its use as an instructional device capable of producing a significant difference in braille reading ability after 20 treatment periods.

Two simple techniques used with the deaf-blind were cubes placed on a board to convey numbers and talking gloves where each finger bore letters and numerals with a seeing person merely touching the appropriate fingers. These gave rise to a more complex educational device such as the "Teletouch," a special communicator developed and manufactured by the American Foundation for the Blind. Depressing keys on a double keyboard, such as found on

either a regular or braille typewriter, resulted in an instantaneous projection of a braille cell. The deaf-blind person tactually perceived this cell in a small display area on the back of the device.

Upon examination of the communication aid, it became even more evident that a braille cell might be presented in such a manner in one of the educational devices for this project. It was decided that an electro-mechanical device, using tachistoscopic principles for single cell presentation, was feasible.

Zahl (1950) stressed that devices for the blind should never be regarded as more than aids. When techniques and knowledge can replace them, every encouragement should be given to their discard. This has been true in the past. Various devices have been discarded when something more functional came into use. But it is important to point out that while some of the devices appeared functionally acceptable, in a mechanical or electro-mechanical sense, their full application was never investigated, modified or transferred for other purposes. It appeared that the devices were often discarded before full utilization of their functions had been determined.

Summary of Educational Devices

Many educational devices were specifically designed for use by the blind but many, reported in the literature as being worthwhile, were apparently never acceptable or useful from a functional standpoint.

There were many attempts to convert conventional print into braille but all were hampered by the fact that they converted to full spelling or grade I braille.

While the tachistotactometer appeared to be an effective diagnostic instrument it did not appear capable of being used optimally for instructional purposes. It was desirable to develop a device that would correct the tachistotactometer's basic limitations. To do this it would seem necessary to add a response panel, a means of indicating success or failure (at the exact point of error), an audible tone for immediate reinforcement, controls for both decreasing threshold stimuli as well as response time, and then to program it to record the essential data automatically.

In summarizing the area of teaching and reading aids, there appeared to be few other than the typewriter and the talking book that have made any great contribution to improving instruction for the blind. Certainly, the functional effectiveness of these devices contributed to their success.

Research supporting the use of "thermoform" materials resulted in the use of this medium in the present experiment. It proved very readable, durable, and reasonable in cost.

Size and cost remain as prohibitive factors limiting most of the educational devices developed for use by the blind. It was felt that eventual simplification, reduction in size and cost of some of the current educational devices may be possible.

Certain electronic devices have successfully served as storage mediums reducing the bulkiness of braille materials. As these are perfected there will be a demand for the development of readout devices to serve and display information in braille.

Lack of success in the area of teaching devices and readout devices establishes a need for research in this area.

Programmed Learning

Programmed instruction is based upon theories that optimum learning will occur when subject matter is logically presented by breaking it into sequential steps thereby maximizing the motivational and meaningful aspects. Accordingly, the program begins with relatively simple concepts and systematically proceeds to the more

complex. Through this step by step progression a student gains an understanding of a subject, by dealing, always, with increments he can handle. Furthermore, he is usually informed of the accuracy of his responses by being provided with the correct answer before proceeding to the next step.

Cook and Mechner (1963) listed the fundamental elements of programmed instruction as active response, small steps, immediate feed-back, low error rate, and self-pacing. Komoski (1963) states

> The best environment for learning is one in which 1. the learner is active; 2. the learner gets frequent and immediate feedback on his performance; 3. learning proceeds gradually from the less complex toward the more complex in an orderly sequence; 4. the learner is allowed to develop his own best pace of learning; and 5. the teacher's strategies are constantly reappraised on the basis of an objective analysis of the learner's activity.

There is limited research involving the use of programming techniques with the blind, and it is therefore essential to include a brief historical summary of the general research in this area. Even though some of it is based upon research with normal rather than the exceptional child, it is of considerable significance to this investigation. Further, the inclusion of teaching machines in this section on programmed instruction is a

result of their mutual interrelationship; in many studies involving programmed learning, teaching machines are involved.

One of the earliest recorded programming devices was used by Dr. Pressey (1926) with a multiple-choice linear program requiring the user to respond to one of four buttons. Only when the correct button was depressed would the program move to the next frame. However, Dr. Pressey's work remained in a dormant stage for quite a few years because of the inability of educators to appraise and recognize its potentiality. Later, Dr. Skinner's work at Harvard provided the spark to rekindle the interest in this area. He demonstrated that conditioning could take place quite rapidly if responses were rewarding and immediately available. This operant or response conditioning resulted in dramatic improvement in the training of animals and has led directly to the recent high interest in machine instruction in the schools.

Stolurow's (1963) survey of research indicated that teaching machines and programmed materials are effective teaching tools. The Pressey approach conceives of teaching devices as one factor in the total instructional effort. The other approach, that of Skinner, views the teaching machine as an independent unit of instruction.

Early studies by Little (1934), Briggs (1950) and Jensen (1949) demonstrated the potentiality of self-instructional devices with high ability students. Dr. Skinner (1954) went further with the thought that "effective instructional devices might wipe out differences in achievement measures associated with intelligence of aptitude test performance." This idea was supported by Porter (1959), Blyth (1960) and Freeman (1959) who observed in their studies that low ability students gained as much and in some cases more than the high ability student. This suggested that a wide span of intellectual ability students might profit from exposure to the programmed sequences than had previously been considered possible. This in itself would further support the utilization of programming techniques.

Dr. Silberman (1962), in reviewing 100 studies involving programmed instruction, has been a leader in calling attention to the need for extensive field testing. Interest among the educational profession, industry, and the public continues to mount as a result of research conducted first in the laboratory and now increasingly in the field.

Finn and Perrin (1962) in a survey of teaching machines and programmed learning for the United States Office of Education introduced a comprehensive overview of information on programmed instruction from industry,

leading researchers and authorities. They pointed out that the rapid expansion of this industry had outdated their report by the time it came off the press.

Studies by Cassidy (1950), Briggs (1950), Jensen (1949), and Severin (1955) are among those that confirmed the usefulness of devices for instructional purposes.

Teaching machine apparatus has also been employed with exceptional children who have learning or sensory disabilities. Detambel and Stolurow (1956), Ferster and Sapon (1958), and Meyer (1959) employing programming principles found a faster rate of learning equal to or exceeding that of the subjects not exposed to programming. Most experimental subjects learned in less time.

Falconer (1960), recognizing the difficulties involved in working with deaf children used a multiple-choice paper-and-pencil test to measure the effectiveness of a programmed course of instruction. Unfortunately, a comparison could not be made because he did not use a control group. However, his results suggested that programmed instruction may be an effective tool in the education of the deaf. Longride (1960) used an audio tape machine to teach speech correction with satisfactory results.

Ashcroft (1963) published a program of braille instruction designed to teach braille to sighted

teachers. It consisted of a visual rather than tactual transmission of information.

Green (1963) used only four blind subjects and a case study approach in an experiment involving programmed instructional material prepared on a "Thermoform" vacuum device. His program consisted of 200 instructional frames of which one half progressed from basic geometric shapes, to other forms, to texture requiring at each step a more difficult tactual or kinesthetic discrimination. The second half was devoted to the use of braille symbols as produced on a standard Perkins Brailler and then re-produced in embossed plastic in the Thermoform vacuum process. He found all subjects gained meaningfully through the use of programmed instruction and interpreted the results as an indication that the program was beneficial and worthy of further experimentation. Limited research in many areas of exceptionality including the blind only reiterate the necessity for more research in this area.

There are differing proponents on practically every aspect of programmed instruction. The question of what is the best way to program materials will find many in agreement with Eigen (1963) who stated that it is improbable that there is any one best way.

Coulson (1962) reviewed more than 100 studies on programmed instruction from 1954 to 1961 plus numerous articles. He found that only 30 per cent of the studies were conducted before 1959 as compared to 70 per cent after 1959. Machines were employed in 45 per cent; 40 per cent of the programs used more than 100 frames; 20 per cent used public school subjects; 40 per cent were in subjects other than mathematics, e.g., science and language; 30 per cent utilized multiple choice responses; and 85 per cent were programmed in linear style.

Stolurow (1963) revealed that data comparing sequenced (linear) with mixed (branching) programs suggest that students learn about the same amount but that different sequences may make different demands upon the students' abilities.

Hughes (1960) tested the effectiveness of programmed instruction compared to conventional lecture-discussion instruction. He used 42 subjects in two control groups and 70 subjects in six experimental groups using either a linear or branching program. He found no significant difference in achievement gain, but a significant amount of time was saved by the programmed group. The branching program was more efficient than the linear program time-wise, but the students expressed attitudes more favorable to the linear program.

Feldhusen (1963) lends support to the use of the linear programs and to the idea that the type of program one should use might well involve the particular purpose and goal in mind.

Consistent exposure to something too difficult is most often unpleasant because of frequent error. However, programmed materials are designed to minimize errors and reinforce the learner. Some negative reinforcement may have positive results (Parry, 1963).

On the question of overt and covert response there appears to be considerable agreement with the findings of Stolurow (1963). He examined the comparative studies of overt and covert response and found that students do as well or better if they are required to read the program without making overt responses, when the program is teaching them something new.

The proper sequence of what is to be learned, the incidence and spacing of cues as well as reinforcement, and the proper amount of repetition can only be ascertained through applied research. A well constructed program is generally more complex and difficult to prepare than a textbook containing the same information. The only way to establish the efficacy of any program is to use it and weigh the results.

Summary of Programmed Learning

It is difficult to come to any conclusions in regard to programmed instruction with the blind because of the sparsity of research in this area. However, a review of programmed instruction in general revealed considerable research.

There appears an almost universal agreement that a teaching machine is only as good as the program it employs, and that a program is only good if it is used and modified until it does what is required.

Programming principles are a result of contributions by various learning theorists, but there is little agreement among the many educators employing programs of varying designs. There are some researchers in this field who feel that there is no best way.

From this investigator's review of the literature it would appear that several statements have some support:

1. Most of the programs are visual, factual, and linear;
2. Programmed instruction may facilitate learning as well or better than conventional instruction;
3. Less time is required to cover material from programmed texts;
4. Covert responses are as effective as overt responses and require less time;

5. Multiple choice response format saves time over constructed responses;
6. Students prefer self-pacing over experimenter paced with little difference in results;
7. Linear programming produces results as effective as branching, but branching saves student time;
8. Programmed texts do not produce meaningfully different results from simple programmed teaching machines; and
9. Students of varying ability levels appear to profit from using the same program.

These findings were supportive of the direction taken in the present study in its inclusion of programming techniques with the blind.

CHAPTER III

METHODOLOGY

On the basis of the review of literature there appears to be little doubt that braille will continue to be an important aspect of any total rehabilitative process for blind adults. However, it is also apparent that we have not been too successful teaching braille to blind adults in the past. It appears a necessity to investigate the reasons why as well as develop new techniques of instruction.

It was the intent of the present investigation to compare programmed materials and teaching machines as supplements to a traditional curriculum of braille instruction with traditional instruction alone.

Subjects

The subjects utilized in this investigation were 31 adult blind, eleven male and 20 female, between the ages of nineteen and 67 attending summer school at the Janesville School for the Visually Handicapped under

the auspices of the State of Wisconsin Division of Vocational Rehabilitation. They were each assigned two periods for braille reading upon their request or, upon the recommendation of their vocational rehabilitation counselor. One-half were randomly assigned to serve as control subjects and the other half as experimental subjects. No attempt was made to match or exclude subjects because of chronological age, mental age, education, or degree, etiology, or length of blindness. These variables, however, when found to have a significant relationship to the criterion measures were covaried in the statistical analysis.

Procedure

The basic aim of this study was to introduce a wide variety of techniques and materials with the hope that different approaches would create significant gains in braille reading. It was hoped that a curriculum approach could be patterned through the use of programmed materials in braille to provide optimum learning regardless of individual differences.

Employing a two by two treatment by level design (Lindquist, 1951), the experimental and control groups were further subdivided for purposes of analysis according to level of reading experience into two groups:

1. those who had no or little braille reading experience (Grade 1 braille), and 2. the better readers who had been exposed and knew some contractions (Grade 2 braille). This permitted a statistical analysis of any interaction effect between the experimental treatment and initial level of braille skill.

All subjects received a total of fifty, 50 minute, periods of instruction on a twice daily schedule. Twenty-five periods of traditional instruction and traditional materials were employed. The other twenty-five periods involved a differentiation of instruction.

In an attempt to keep any "Hawthorne Effect" (Cook, 1962) to a minimum, the same instructor employed traditional instructional methods for both the control and experimental groups during their first hour of instruction while additional licensed instructors of the blind rotated between the experimental and control subjects during the second hour of instruction.

During this second hour, the experimental subjects were exposed to three levels of training: 1. pre-reading and initial reading training on a series of graphic tactual discriminations graded for difficulty level, followed by a program of braille character discriminations using a self-paced teaching (Device #I) and program display apparatus; 2. a program of

momentary or tachistoscopic presentation of braille symbols through use of an automated learning machine (Device #II) designed to increase accuracy and speed of recognition; 3. a program of braille on tape using a tape reader (Device #III) where the speed was controlled by either the subject or the instructor.

Control subjects were exposed for an equal amount of time for the learning of braille, but they received the same basic materials through traditional instruction without the aid of programs or automated devices.

Assessments

Based on analysis of the literature and consultations with the Faculty Advisory Committee at the Janesville School for the Visually Handicapped, it was decided to use several assessment devices:

1. A pre and post braille reading test, measuring speed and accuracy, developed from Science Research Associates material. Counting devices were used for tabulating errors, retracings, up and down movement of fingers, additions, omissions and faulty transfers from line to line. (Appendix A)
2. Pre and Post Tactual Discrimination Tests were developed to measure the tactual

discrimination ability of non-braille and beginning braille readers. (Appendix B)

3. A recognition test was developed from a random assortment of braille configurations (alphabet, punctuation and contractions) as a final assessment device to determine accuracy and speed of perception. (Appendix C)

4. The verbal section of the Wechsler Adult Intelligence Scale was utilized.

5. The Wide Range Reading Test was administered orally to assess word recognition ability. (Appendix D)

6. The Internal Locus Control Test served as an assessment of personality. (Appendix E)

7. Unstructured Pre and Post reactions on instructional techniques, materials, and teaching machines were recorded and evaluated.

Educational Device I and Program

This educational device (See Appendix F) is a modified code oscillator about 1" x 2" x 4" with a small earphone and stylus attached. It uses a number of programmed instructional materials especially prepared on a thermo-form press that offers each subject the opportunity of a multiple choice response. The

correct response is indicated by applying the stylus to a small circular patch of conductive paint and a pleasant positive reinforcement is produced through the earphone. A matching color, but non-conductive paint under the incorrect responses does not produce any sound. The subject then knew he had made a wrong response.

The response items are placed symmetrically below each item so the subject can accurately indicate his choice. The paint, both conductive and non-conductive, is placed in an elevated and indented circle, which is easily identified because of placement and elevation.

The programmed instructional materials of 200 frames (Appendix F) used with this machine were oriented toward developing and increasing tactual and kinesthetic discriminatory abilities. A wide variety of materials with variable dimensions of shape, size and texture were presented. Complexity increased from more gross discriminations involving first, basic geometric shapes, then form, to texture (fabric), and finally, braille configurations.

The programs were introduced in a linear fashion enabling each subject to make an active response, progressing at his own individual speed, receiving immediate reinforcement and an indication of progress (Appendix G).

Each subject was able to maneuver the program and apparatus from frame to frame with little difficulty. Two storage areas were conveniently located for the subject to accept a new frame, dispense with it and move to the next.

Education Device #2 and Program

This device (Appendix H) presented a braille cell under a duration control. It introduced braille symbols at a tactual exposure time matching the subject's ability to perceive them. Duplication of the presented braille symbol was made on six response buttons which were set in two columns consistent with the braille cell. Depression of the response buttons matching the previously presented braille symbol produced an auditory signal which served as a cue to the learner that his response was correct. Depression of an incorrect pattern produced a noxious signal and brought about re-presentation of the symbol until the correct response was made.

The purpose of this machine was to facilitate an increase in the speed of discrimination and recognition of braille symbols. The braille configurations were presented in a linear program consisting of <u>metal strips</u> inserted into the machine.

The program used with Machine 2 consisted of 270 frames on nine aluminum strips containing 30 frames each. (Appendix H) Basically the first ten letters of the alphabet were introduced on strips one through two; the second 10 letters on three and four; the first 20 letters combined were on five and six; the last 6 on strip seven, and all letters on strips eight and nine.

The Device #2 program involved the necessity of the subject making a correct overt response before the program advanced to the next frame. The machine was paced by the experimenter as determined by the subject's threshold recognition and response time.

The Device #2 program, while being linear, was segmented so that repetition of a particular segment could be obtained if the subject or instructor, so desired. This would qualify it, to some degree, as being a branching program.

Educational Device #3 and Program

This device (Appendix I) is a tape reader that introduces braille on tape 5/8 inches wide moving from right to left across a presentation window at speeds from 0 to 500 words a minute under conditions in which the fingers were for the most part stationary. However, the presentation window was wide enough to permit some, but limited, retracing.

The availability of materials was virtually unlimited as a wide variety of written material was prepared for presentation on this machine. Programming principles were employed in presenting comprehensive check test questions followed by a blank tape space during which a covert response could be made before the answer was provided on the tape. The speed of operation of this Tape Reader could be adjusted either by the subject or experimenter.

Over two miles of thermoformed plastic tape (Appendix I) were prepared encompassing all ability levels extending from beginning braille to Grade II braille. Each foot of tape contained about 10 or 11 words. These materials were categorized into graded vocabulary and interest levels. Resources used in the production of these tapes include reading material provided by <u>Science Research Associates</u>, <u>Reader's Digest</u>, and other resources. A total of fifty stories were prepared on tape of varying levels of reading difficulty covering a wide variety of high interest factual, fictional, and recreationally oriented material. High interest, low vocabulary materials were prepared for those adults with limited reading ability. The materials were introduced in a sequential fashion.

CHAPTER IV

RESULTS AND DISCUSSION

Study Sample Analysis

All subjects were Wisconsin Vocational Rehabilitation clients selected from Wisconsin's adult blind population. The selection factor (selection of younger clients because of rehabilitative potential) accounted for the inclusion of a sample having a mean CA 20 years lower than the mean CA for the state (Table I). This also affected the comparative age mean of onset of blindness. The diabetically induced blind were over represented in the research sample because diabetes was an early cause of blindness among these subjects, but the incidence of diabetically induced blindness did not correlate significantly with any other variable.

A lower proportion of males was the only other difference between the sample under study and Wisconsin's adult blind population. None of these before mentioned variables correlated significantly

TABLE I

COMPARISON OF THE VITAL STATISTICS OF THE BLIND POPULATION IN THE STATE OF WISCONSIN AND THE SAMPLE UNDER STUDY

	Study Sample	Wisconsin[1]
INCIDENCE OF BLINDNESS		
Male	35.5%	52.8%
Female	64.5%	47.2%
Chronological Age (Mean)	46.4	66.4
Over 55	32.3%	66.6%
Between 16 - 35	22.6%	11.1%
Age of Onset (Mean)	29.8	44
Blind after 30	54.8%	67%
Blind at birth	22.6%	16%
White Race	96.8%	97.1%
Gainfully Employed	25.8%	28.6%
Totally Blind	12.9%	20%
Legally Blind	87.1%	80%
CAUSE OF BLINDNESS		
Infectious Disease	6.4%	6.0%
Accident	6.4%	8.0%
Other Disease	19.3%	16.0%
Diabetes	19.3%	7.5%
Unknown	48.6%	62.5%

1 "Services to the Blind in Wisconsin," State Department of Public Welfare, 1961.

with any other variable and did not appear to consequently influence our results.

The salient characteristics of the adult blind were examined by levels and treatment groups (Table II), there did not appear to be any apparent differences except that level I groups were generally poorer braillers because they had had a shorter exposure to braille instruction. A significant correlation was found with the age of onset of blindness and pre-test braille reading assessment. The longer a person had been blind, the more likely he was a better braille reader.

Examining the data on the psychological and educational aspects of all subjects in Table II revealed little variation. I.Q. (WAIS), Vocabulary (WAIS), Wide Range Reading, Education and Internal Locus of Control (ILC) intercorrelated significantly (except that ILC did not correlate with Education) suggesting that the subjects' scores on these measures were directionally positive. Close comparison of each of these variables with braille reading success revealed that Education, Wide Range Reading and Vocabulary correlated significantly with the blind adult's ability to read single cells in the Cell Test but not with the total time used when the students were allowed to take all the time they needed. A negative correlation between the cell test

TABLE II

COMPARISON OF THE SALIENT CHARACTERISTICS OF THE EXPERIMENTAL AND CONTROL GROUP MEANS

	Level I		Level II		Total	
	E	C	E	C	E	C
Chronological Age	49.4	45.8	49.1	42.2	49.3	44.2
Length of Blindness	7.4	7.6	29.8	26.6	17.9	15.9
I.Q. (Verbal WAIS)	111.9	109	99	114.0	106	111.2
Vocabulary (WAIS)	53.3	47.3	48.9	56.6	51.2	51.4
Wide Range Reading	10.3	10.2	11.3	12.2	10.8	11.1
Education	10.8	11.44	10.6	10.86	10.7	11.2
ILC	6.0	7.1	6.0	6.0	6.0	6.6

score and the time used revealed that those who scored higher on the cell test tended to use less time.

However, on all other assessments such as the Tactual Discrimination Test, the Braille Reading Test (words correct), and recognition time per cell on the Cell Recognition Test, there was no significant correlation with I.Q., Education, Vocabulary, Wide Range Reading or the Internal Locus Control. This indicates that these measures, as used in this study, were not good predictors of braille reading success.

However, the number of learned dot configurations (total cells learned) to these measures is positively correlated when time was not a factor. This lends support to the basic idea that most adults, even with limited training, can tactually learn to perceive the various cell combinations if speed of perception is not a factor. The actual speed of these perceptions is related to the tactual sensitivity of the finger/s and the additive association of cells into words. These concepts will be discussed in detail with the examination of the results of the specific assessments employed in ensuing sections.

<u>Braille Reading Test</u>

A reading test measuring speed and accuracy was prepared in grade I braille (full spelling) for

beginning braillers (level I) and the same test was prepared in grade II braille (level II contracted form) for the better braillers.

Table III shows the recorded mean and ranges of the pre and post test scores for the control and experimental groups and levels. Inspection of gain scores and percentage of gain scores directionally and proportionately favored the experimental subjects after 25 two hour treatment periods.

The charts in Figures 1, 2, and 3 illustrate the changes in the braille reading speed for the experimental and control groups over the summer session period. These differences between the two groups favored the experimental group by each level and the combined total of both levels.

Although subjects were sampled randomly a slightly skewed sample of better braillers got into the experimental group. The initial test difference was not significant at the .05 level. However, these initial score differences did suggest an influence on our results and it was necessary to covary them out in the final analysis (Table IV).

The initial differences between levels was significant, (.001) favoring level II because the levels were determined by the subject's ability to read braille.

TABLE III

COMPARISON OF SPEED OF READING BRAILLE PER FIVE MINUTE TEST

	Level I				Level II				Levels Combined			
	Experimental		Control		Experimental		Control		Experimental		Control	
	$\bar{X}$	Range	$\bar{X}$	Range	$\bar{X}$	Range	$\bar{X}$	Range	$\bar{X}$	Range	$\bar{X}$	Range
Pre Score	3.5	0-11	4.7	0-10	208.8	26-393	96.1	10-375	99.2	0-393	44.7	0-375
Post Score	9.5	1-22	8.0	0-16	249.1	41-481	98.7	6-356	121.3	1-481	47.7	0-356
Gain Score	6.0	--	3.3	--	40.3	--	2.6	--	22.1	--	3.0	--
% Gain	172	--	70	--	19.4	--	2.7	--	22.3	--	6.5	--

FIGURE 1

PRE AND POST MEAN WORDS READ SUCCESSFULLY PER FIVE MINUTES BY LEVEL I AT FIRST AND TWENTY FIFTH PRACTICE SESSION

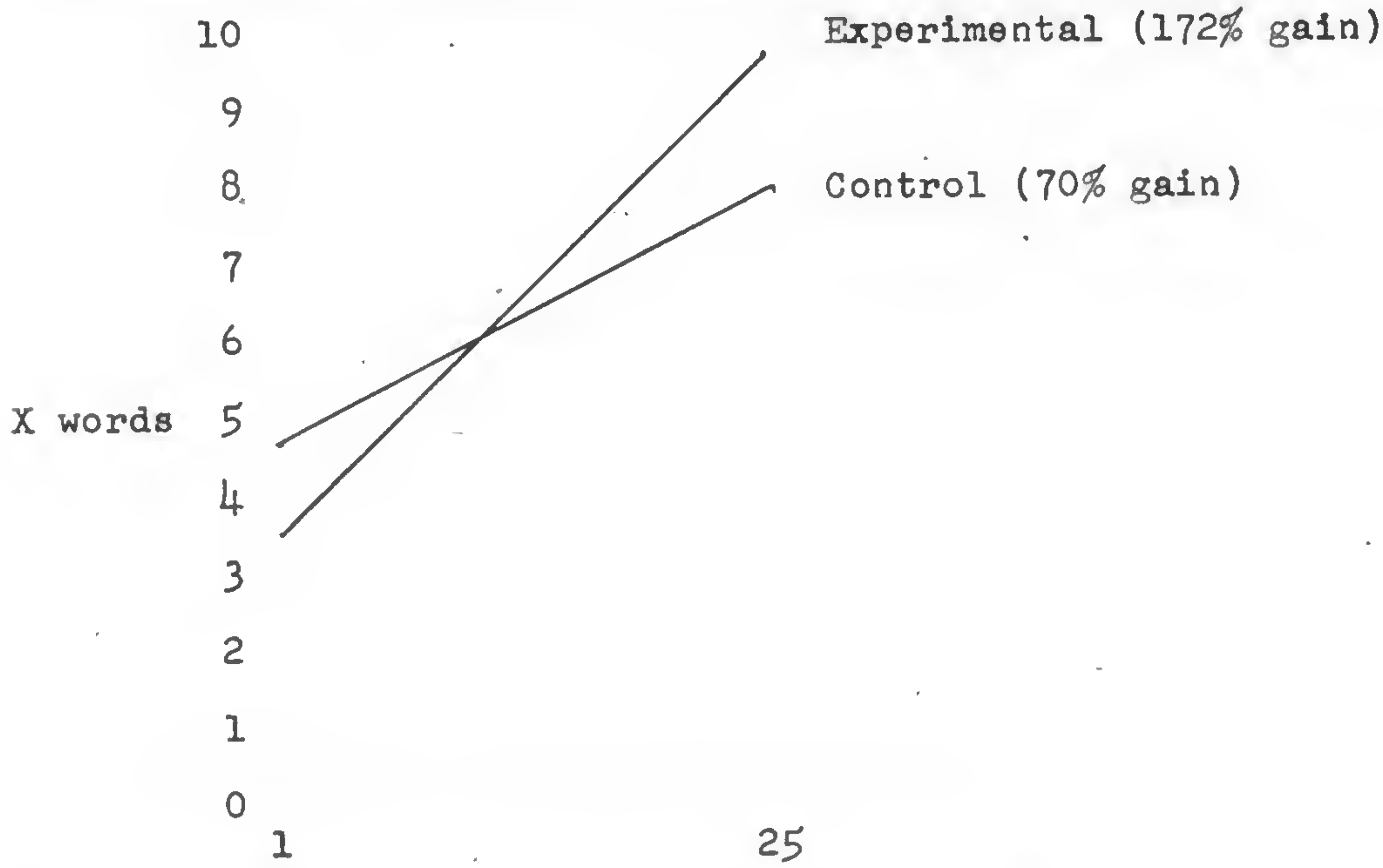

FIGURE 2

PRE AND POST MEAN WORDS READ SUCCESSFULLY PER FIVE MINUTES BY LEVEL II AT FIRST AND TWENTY FIFTH PRACTICE SESSION

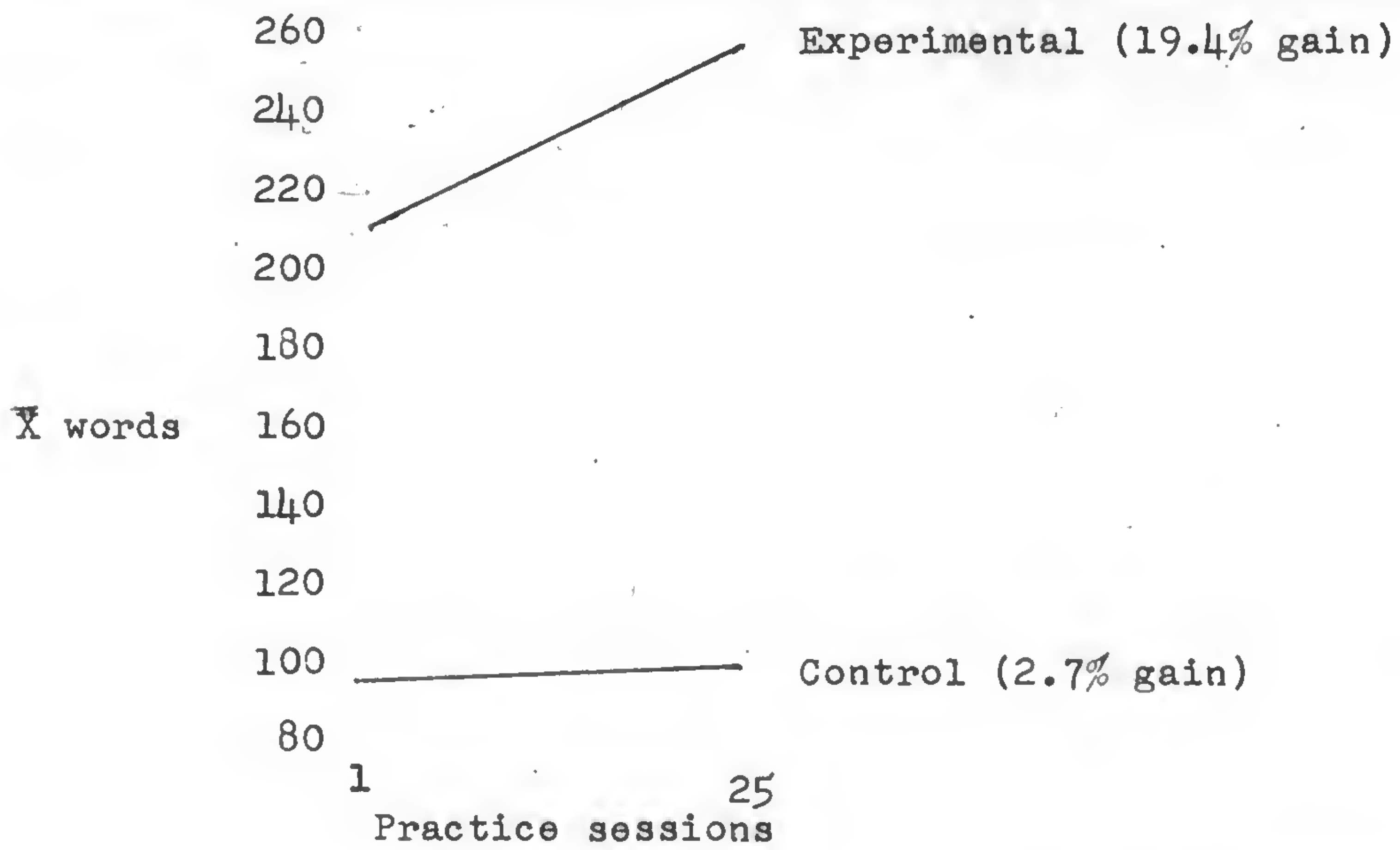

FIGURE 3

PRE AND POST MEAN WORDS READ SUCCESSFULLY PER FIVE MINUTES BY COMBINED LEVELS AT FIRST AND TWENTY FIFTH PRACTICE SESSION

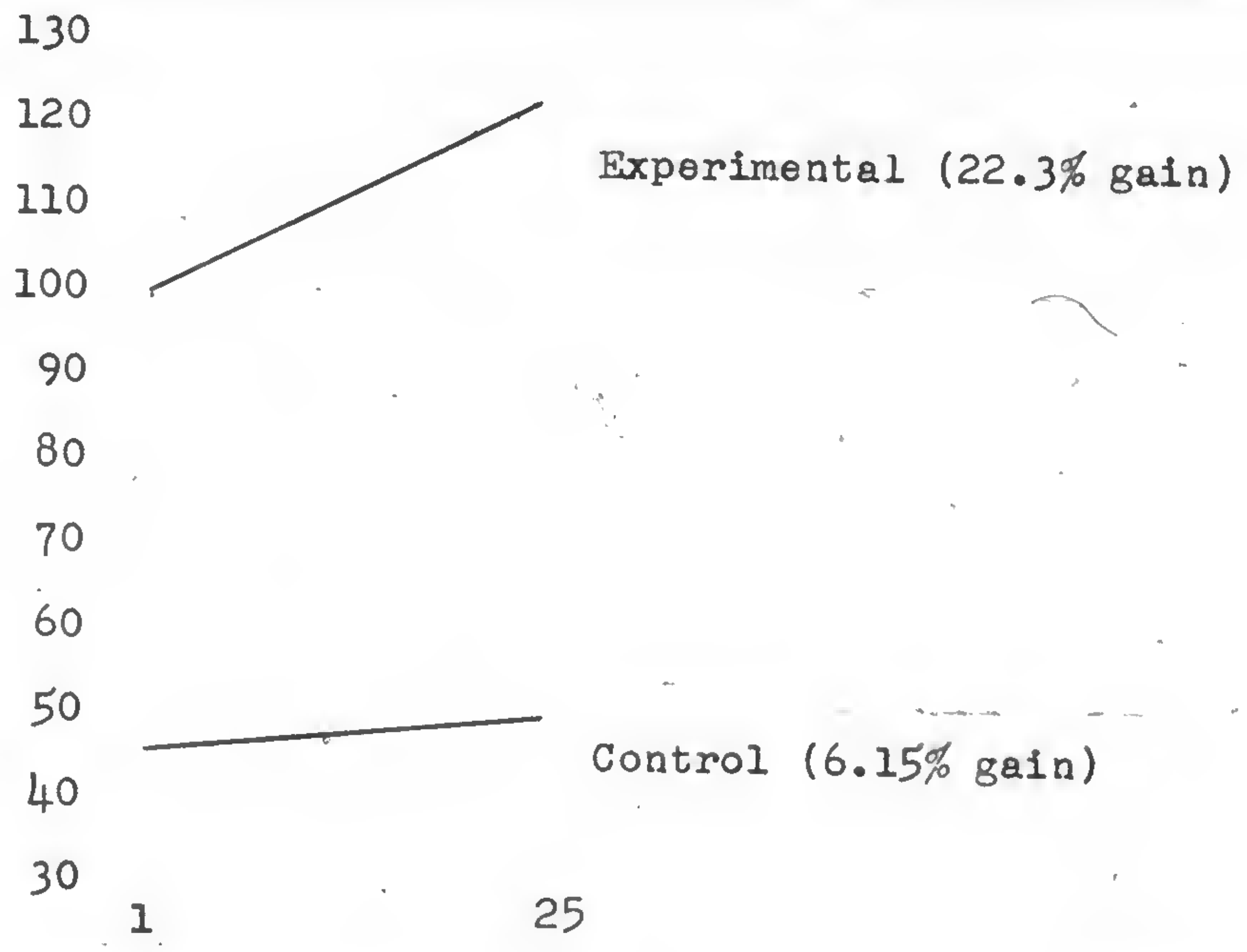

TABLE IV

STATISTICAL ANALYSIS[1] OF SPEED AND ACCURACY TEST

Initial Measures

Source	df	SS	MS	F	P
Groups	1	25,032		2.97	.1
Levels	1	174,197		20.37	.001
Groups x Levels	1	25,595		3.05	.1
Error	27	226,832	8,401.2		
Total	30	451,656			

Gain Measures (without covariance)

Source	df	SS	MS	F	P
Groups	1	3,444		6.19	.05
Levels	1	2,278		4.09	.055
Group x Levels	1	2,521		4.50	.05
Error	27	15,005	555.6		
Total	30	23,248			

Gain Measures (Initial measures covaried out)

Source	df	SS	MS	F	P
Groups	1	1,747	1,747	3.61	.1
Levels	1	47	47	.097	
Group x Levels	1	1,126	1,126	2.32	.15
Error	27	13,060	483.7		
Total	30	15,980			

1 Initial levels covaried out, 2 x 2 design with unequal cells, least squares solution used. (Winer page 594.)

Gain score differences by groups were significant at the .05 level favoring the experimental subjects. Gain score differences by level were less significant (.055) than in the initial test measures. This was probably due to the larger percentage of gain by level one because a number of subjects were learning braille for the first time. These proportionate gains were higher for level I than level II.

Interaction between groups and levels was only significant on the gain measures. This appeared to be related to the fact that all groups and all levels gained in braille reading. These differences probably resulted from the random sampling of subjects into groups which were not equal in braille reading ability as we would have liked. This was evident from the initial test differences.

The gain score measures with the initial measures covaried out continued to support the trend favoring the experimental subjects but at a level of significance at or near the .05 level.

Braille Reading Errors

The initial error rate for the subjects who had known braille (error rate not computed for non-braillers) was not found to be significant between groups at the .05

level. However, as we examine the error gain score differences (a decrease was desirable) a significant difference at the .01 level favoring the experimental group was found (Tables V and VI).

The experimental group had a mean decrease of 5.3 errors while the control group had a mean decrease of 1.0 errors. On a percentage basis there was a decrease of 71.6 to 18.05 in favor of the experimental subjects.

Braille Reading Retracing Movements

Comparison of the initial retracing score differences (Tables VII and VIII) showed a significant difference favoring the control group as having fewer number of retracing movements. The experimental group had a proportionately higher retracing rate. Comparing both groups on retracing gain score differences resulted in a significant decrease in this undesirable finger movement for the experimental group. The control group, on the other hand, had a slight increase (undesirable) in the number of retracing movements. The control retracing scores compiled at the close of the practice sessions ended with a mean about 2½ times that of the experimental group, while initially having only ½ times as many retracing movements. The experimental group evidenced a 77 per cent or mean decrease of 25.5 retracings compared to a 10.8 per cent gain of 1.42 retracings for the control

TABLE V

PRE, POST AND GAIN SCORE, MEAN, RANGE AND PER CENT OF GAIN ON ERRORS DURING FIVE MINUTE BRAILLE READING TEST (BEGINNING BRAILLERS EXCLUDED)

	Experimental (N=10)		Control (N=12)	
	$\bar{X}$	Range	$\bar{X}$	Range
Pre Score	7.4	2 to 17	5.42	0 to 12
Post Score	2.1	0 to 12	4.42	0 to 12
Gain Score	-5.30	-13 to 0	-1.0	-5 to +7
Per cent of Gain	71.6 (decrease)	--	18.05 (decrease)	--

TABLE VI

T TEST ANAYLSIS OF ERROR FREQUENCY

E vs C	df	difference	t^1	p*	Conclusion
Pre Score	20	1.98	1.04	.15	$E \geqq C$
Gain Score	20	4.3	2.60	.01	$E < C$

1 t-test (Winer, p. 32)

* Student's Distribution (Walker and Lev)

TABLE VII

PRE, POST AND GAIN SCORE MEAN, RANGE AND PER CENT OF GAIN ON RETRACINGS (HORIZONTAL MOVEMENT) DURING FIVE MINUTE BRAILLE READING TEST (BEGINNING BRAILLERS EXCLUDED)

	Experimental (N=10)		Control (N=12)	
	$\bar{X}$	Range	$\bar{X}$	Range
Pre Score	33.1	14 to 61	17.33	5 to 46
Post Score	7.6	3 to 21	18.75	8 to 37
Gain Score	-25.5	-53 to -11	+ 1.42	-1 to +8
Per cent of Gain	77% (decrease)	--	8.2% (decrease)	--

TABLE VIII

T TEST ANALYSIS OF RETRACING FREQUENCY

E vs C	df	difference	t[1]	p*	Conclusion
Pre Score	20	15.77	2.62	.01	E > C
Gain Score	20	24.08	6.80	.0005	E < C

1 t-test (Winer, p. 32)

* Student's Distribution (Walker and Lev)

group. These differences were significant at the .005 level of confidence.

Braille Reading Up-Down Movements

There was no significant difference between the experimental and control groups on initial up-down movement scores (Tables IX and X). However, the experimental group mean gain score difference decreased by 14, a percentage decrease of 51.9, while the control group increased by 4.17, and a percentage gain of 15.3. This difference was significant at the .005 level.

Transfers, Reversals and Omission Errors

It is clear from the data (Table XI) on errors of transfer, reversal, and omission were too infrequent to provide us with any statistical inference.

Tactual Discrimination Test

Inspection of the results of the Tactual Discrimination Test, administered to level I only, revealed an initial pre-score difference favoring the control group. This difference, while it significantly favored the control group initially, reversed itself when we examined the post score difference (Table XII).

Examination of the gain scores revealed a 74.9 per cent increase for the experimental S's and a 27.4 per cent

TABLE IX

PRE, POST AND GAIN SCORE MEAN, RANGE AND PER CENT OF GAIN ON UP-DOWN (VERTICAL MOVEMENT) DURING FIVE MINUTE BRAILLE READING TEST (BEGINNING BRAILLERS EXCLUDED)

	Experimental (N=10)		Control (N=12)	
	X	Range	X	Range
Pre Score	29.1	2 to 63	27.33	0 to 47
Post Score	15.1	0 to 30	31.50	0 to 56
Gain Score	-14.0	-33 to +2	+ 4.17	0 to 24
Per cent of Gain	51.9% (decrease)	--	15.3% (increase)	--

TABLE X

T TEST ANALYSIS OF UP DOWN MOVEMENT FREQUENCY

E vs C	df	Difference	t^1	p*	Conclusion
Pre Score	20	1.77	.239	NS	E = C
Gain Score	20	18.17	4.23	.0005	E < C

1 t-test (Winer, p. 32)

* Students Distribution (Walker and Lev)

TABLE XI

COMPARISON OF PRE AND POST TOTALS ON TRANSFER, REVERSAL AND OMISSION ERRORS

	Transfer[1]		Reversal[2]		Omission[3]	
	E	C	E	C	E	C
Pre	3	3	2	0	0	0
Post	4	6	3	3	3	4

1 Errors total of these three types were too few in number to be treated by statistical analysis.

2 Error of this type limited to line or page.

3 Error of this type limited to word only.

TABLE XII

PRE, POST AND GAIN SCORE MEAN AND RANGE OF THE TACTUAL DISCRIMINATION TEST ADMINISTERED TO LEVEL I ONLY

	Experimental		Control	
	$\bar{X}$	Range	$\bar{X}$	Range
Pre Score	52.25	16-86	85.89	29-150
Post Score	91.38	43-129	109.45	55-150
Gain Score	39.13	14-83	23.56	34-71
Per Cent of Gain	74.9%	--	27.4%	--

for the control S's. These gain score differences were significant at .15 which is only indicative of a trend favoring the experimental S's. When the initial test score differences (Table XIII) were covaried out, we found less statistical evidence supporting the experimental group.

It was interesting to note that while all experimental S's increased their scores only seven of 9 had done so for the control group.

The Tactual Discrimination Test was only used as an assessment device with level I braillers. Further examination of the results of this assessment device was made when the results of the other measures used on the same subjects were inspected.

<u>Comparison of Cell Test Score Differences</u>

At the conclusion of the study, a cell test was given to all subjects. It consisted of three subtests: alphabet, punctuation, and contractions. The subjects proceeded at their own pace, and the total time and number correctly read were computed and totaled for each subtest. Table XIV shows the means and ranges for each level and group. From inspection, there was little difference between the treatment groups in terms of subtest or total scores. However, when the total time to

TABLE XIII

STATISTICAL ANALYSIS OF TACTUAL DISCRIMINATION TEST

Pre Measure

Source	df	SS	MS	F*
Between	1	4,792.5		3.94
Within	15	18,304.4	1,220.3	
Total	16			

Post Measure

Source	df	SS	MS	F
Between	1	1,382.8		1.37
Within	15	15,124.1	1,008.3	
Total	16			

Post Measure (Pre measure covaried out)[1]

Source	df	SS	MS	F
Between	1	13.5	13.5	<1
Within	15	8,599.2	614.2	
	16	8,612.7		

1 Initial levels covaried out, 2 x 2 design with unequal cells, least squares solution used. (Winer page 594).

* $p = .05$

TABLE XIV

COMPARISON OF TREATMENT GROUP SCORES ON CELL TEST AT CONCLUSION OF STUDY

	Level I			Level II			Combined		
		$\bar{X}$	Range		$\bar{X}$	Range		$\bar{X}$	Range
Alphabet									
Experimental	N=8	28.4	17-47	N=7	48.9	40-50	N=15	37.0	17-50
Control	N=9	39.0	21-49	N=7	45.1	39-50	N=16	42.1	21-50
Punctuation									
Experimental	N=8	4.8	0-16	N=7	13.6	4-19	N=15	8.9	0-19
Control	N=9	7.8	0-19	N=7	14.6	10-20	N=16	10.8	0-20
Contraction									
Experimental	N=8	14.8	0-26	N=7	25.29	20-29	N=15	19.67	0-29
Control	N=9	11.4	0-28	N=7	26.14	22-29	N=16	17.88	0-29
Total test									
Experimental	N=8	57.9	17-89	N=7	85.71	62-98	N=15	70.87	17-98
Control	N=9	58.2	21-96	N=7	86.71	73-99	N=16	70.69	21-99
Total time[1]									
Experimental	N=8	774.5	550-1265	N=7	351.0	104-717	N=15	576.8	104-1265
Control	N=9	885.6	213-1920	N=7	501.8	111-1205	N=16	717.8	111-1920
Time per cell[1]									
Experimental	N=8	13.4	6.9-32.3	N=7	4.1	1.1-10.3	N=15	8.0	1.1-32.3
Control	N=9	15.2	4.9-66.2	N=7	5.8	1.1-14.0	N=16	10.1	1.1-66.2

1 Time in seconds

complete the test or the time per cell (correct) was calculated, trends were found supporting the experimental group. None of the test score mean differences were significant. Because this test was not available as a pre-test it was not possible to make a comparison with initial test scores because they were unknown except for the beginning braille readers who would, in all probability, have had zero initial scores (Tables XVI and XVII).

Other Trends

Examination of the results of the pre and post measures of the Braille Reading Test, Reading Errors, Retracings, Up-Down Movements and the Tactual Discrimination Test revealed some meaningful trends. The direction of these desired trends supported the experimental group on all measures at both levels.

Level I had a smaller intra group difference (100 per cent to 66 per cent), favoring the experimental group. Level II had a larger intra group difference (92.2 per cent to 35.7 per cent) again favoring the experimental group. Total desired gain score differences computed on a percentage basis were 95.6 per cent to 47.7 per cent (Table XV). Approximately one-half of all non-treatment group measures resulted in undesirable trends as compared to about

TABLE XV

SUMMARY OF TRENDS

Measure	Level I E	Level I C	Level II E	Level II C	All Levels E	All Levels C
Braille Reading Test						
Increase (desired)	8	6	6	2	14	8
Decrease	0	3	1	5	1	8
Reading Errors						
Decrease (desired)	3	3	6	4	9	7
Increase	0	2	1	3	1	5
Retracing						
Decrease (desired)	3	2	7	3	10	5
Increase	0	3	0	4	0	7
Up Down Movement						
Decrease (desired)	3	4	7	1	10	5
Increase	0	1	0	6	0	7
Tactual Discrimination Test						
Increase (desired)	8	7	-	-	-	-
Decrease	0	2	-	-	-	-
Desired Total	25	22	26	10	43	25
Undesired Total	0	11	2	18	2	27
Desired Percentage	100	66	92.2	35.7	95.6	47.7

5 per cent for the treatment group. Inspection of the trends support the findings of the statistical analysis of these measures.

Comparison of Beginning Braillers on all Measures

Nine of the subjects in level I were beginning braille readers, and it seemed advisable to examine their results of all the measures used (Table XVI) apart from the other subjects in level I who had known some braille. Directionally desired gains were found favoring the experimental subjects on all but the punctuation subtest of the "Cell Test."

Discussion with the staff at the close of the project revealed that inquiries concerning punctuation were frequently made by the control subjects and less frequently by the experimental subjects. Those subjects using programmed instructional materials had less opportunity for inquiry.

Further examination of the Cell Test results revealed a "time per cell," for the experimental group approximately one-half that of the controls. The "cell test time" of all levels and groups correlated significantly with pre and post braille reading speed as well as with previous amount of braille instruction and age of onset of blindness, as we might predict.

TABLE XVI

COMPARISON OF BEGINNING BRAILLERS FROM BOTH TREATMENT GROUPS[1]

	Experimental (N=5)		Control (N=4)	
	$\bar{X}$	Range	$\bar{X}$	Range
Alphabet	35.2	17-42	31.0	21-44
Punctuation	.2	0-1	4.0	0-10
Contraction	8.8	0-25	6.5	0-23
Total Cells[2]	44.2	17-65	41.5	21-77
Total Time[3]	837.6"	550"-1265"	1368.0"	740"-1920"
Time Per Cell[3]	19.1"	13.1"-32.4"	33.0"	13.6"-66.2"
Words Gain[1]	5.2	1-11	5.0	0-14
Retracings	7.0	0-20	26.3	3-46
Errors	4.6	1-11	4.8	2-8
Up Down	19.6	7-32	48.3	9-100
TDT Pre	49.4	16-86	56.8	29-86
Post	81.0	43-129	83.0	55-109
Gain	31.6	14-52	26.3	21-35
% Gain	63.9		46.4	

1 Pre scores on Braille reading were assumed to be zero for all subjects.
2 N.S.
3 Sign. difference favoring experimentals at .05

Examination of the remaining measures revealed a considerable difference in retracing and up-down movements favoring the experimental subjects. The TDT score differences supported the experimental group.

Examining the statistical results of T-Test Analysis of all measures (Table XVII) revealed a significant difference at the .05 level favoring the experimental subjects on total cell test time and reduction of retracing movements. Reduction of up-down movements, reading errors, and time per cell were noted.

Generally, the same pattern of significant differences and trends supported for the beginning braillers in this group of experimental subjects were the same as was found for the total group of experimental subjects having varied levels of braille reading ability.

Quantitative Characteristics of Sample Under Study

The sample used in this investigation involved 11 male and 20 female subjects. Our randomly assigned groups were not as evenly represented by sex as desirable (Table XVIII). However, sex differences did not correlate with any of our test measures and therefore probably did not appear to influence our results.

Correlations run on the total number of years of previous summer school attendance at Janesville or on previous braille instruction were significant only in

TABLE XVII

T TEST ANALYSIS OF BEGINNING BRAILLER GAIN SCORES ON ALL MEASURES

Measure	df	$\bar{\bar{X}}$ Difference	t	p	Conclusion
Total Cells Correct	7	2.7	.365	NS	E = C
Total Time	7	530.4	2.06	.05	E < C
Time Per Cell	7	19.0	1.74	.1	E ≦ C
Words Correct	7	.2	.075	NS	E = C
Retracings	7	18.75	2.11	.05	E < C
Errors	7	1.85	1.17	.15	E ≦ C
Up Down	7	28.65	1.48	.1	E ≦ C
TDT Gain[1]	7	5.35	.153	NS	E = C

1 All measures except the Tactual Discrimination Test had zero pretest scores.

TABLE XVIII

QUANTITATIVE CHARACTERISTICS OF POPULATION SAMPLE

		Level I		Level II		Total	
		Exp.	Control	Exp.	Control	Exp.	Control
Male		2	5	0	4	2	9
Female		6	4	7	3	13	7
Fingers Used							
Right Index		3	6	3	3	6	9
Left Index		4	2	2	3	6	5
Both		1	1	2	1	3	2
Other Fingers		0	2	0	0	0	2
Both Hands		1	2	2	1	3	3
Previous Summer Schools Attended							
Number	0	4	5	2	1	6	6
	1	1	1	0	3	1	4
	2	2	1	2	1	4	2
	3	0	1	0	2	0	3
	Over	1	1	2	0	3	1
Future Participant							
Yes		7	7	7	6	14	13
Maybe		1	2	0	1	1	3
No		0	0	0	0	0	0

the area of pre-braille reading ability. This correlation would be expected because of the zero scores recorded for the non-braillers. Progress in braille reading ability (post test scores) as a result of this experiment did not appear related to previous summer school or braille reading instruction.

Almost all of the subjects indicated they would be willing to participate again at a future date in a similar project. There were reservations on the part of four subjects but all others clearly indicated a strong interest in being a future participant. This did not appear to correlate with any other particular variable. However, it did reflect the absence of a "Hawthorne Effect" which might have affected our results. This in essence was also a reflection of interest shown on the part of the control S's equal to that of the experimental S's.

Other Considerations

Second and twenty second day unstructured reactions to the project were also recorded (Tables XIX and XX). The 3 to 1 ratio of positive to negative responses (includes constructive criticisms) were about equal for both groups. However, more responses were recorded for the experimental group than the control group. This was

TABLE XIX

SECOND AND TWENTY SECOND DAY CONTROL REACTIONS TO PROJECT BY FREQUENCY OF RESPONSES RELATING TO INSTRUCTION

Context of Response	Pre	Post	Total
Interesting stories, material	6	5	11
Happy to be participant	3	4	7
Enjoyable, likeable, fun, good	3	3	6
Opportunity to practice	1	3	4
Helpful	1	3	4
Liked the plastic sheets	1	3	4
Wanted to know more about experimental group	0	4	4
[1]Difficult to feel Braille on finger	2	1	3
[1]Disliked plastic sheets	2	1	3
[1]Dots rounded too much	1	1	2
Learn to read faster	1	1	2
Learned a lot	0	2	2
[1]Work too hard	0	2	2
[1]Didn't learn much	0	1	1
Challenging work	0	1	1
[1]Not enough help	0	1	1
Progressing	0	1	1
[1]Sweaty fingers	1	0	1
Found no printing errors	0	1	1
Experimental would be more interesting	0	1	1
Positive	16	32	49
Negative	6	7	13
Totals	22	39	61

1 Negative response

TABLE XX

SECOND AND TWENTY SECOND DAY EXPERIMENTAL REACTIONS TO PROJECT BY FREQUENCY OF RESPONSE RELATED TO MACHINES AND PROGRAMS

Context of Response	Reaction to #I Pre	#I Post	#I Total	#II Pre	#II Post	#II Total	#III Pre	#III Post	#III Total	Cumulative Total
Enjoyable, likable, fun, good	6	6	12	5	4	9	6	6	12	33
Increase reading speed	0	1	1	2	4	6	5	7	12	19
Interesting, fascinating	2	1	3	5	2	7	4	1	5	15
Easy, not difficult	5	3	8	1	2	3	1	3	4	15
[1]Too easy, better for kids	9	4	13	0	0	0	0	2	2	15
Tells me right from wrong	1	1	2	2	4	6	0	0	0	8
Increase finger sensitivity	1	1	2	1	2	3	1	0	1	6
[1]Not sure of worth	1	1	2	0	1	1	1	2	3	6
[1]Noise bothers me	0	0	0	0	2	2	1	2	3	5
[1]Can't retrace	0	0	0	0	0	0	2	3	5	5
[1]Cell should stay up longer	0	0	0	2	2	4	0	1	1	5
Need more practice	2	0	2	2	0	2	0	0	0	4
Like holding hand in one spot	0	0	0	0	0	0	1	2	3	3
Challenging	1	0	1	1	1	2	0	0	0	3
[1]Hard	0	0	0	1	1	2	0	1	1	3
[1]Trouble hearing sound	2	0	2	0	0	0	0	0	0	2
[1]Can't figure out mistakes	0	0	0	1	1	2	0	0	0	2
[1]Trouble distinguishing shapes	1	1	2	0	0	0	0	0	0	2
[1]Tiring, fingers tired	0	0	0	0	0	0	0	2	2	2
Not tiring	0	0	0	0	0	0	1	0	1	1
[1]Long procedure	0	1	1	0	0	0	0	0	0	1
Sequence good	1	0	1	0	0	0	0	0	0	1
I don't lose my place	0	0	0	0	0	0	0	1	1	1
Positive	19	13	32	19	19	38	19	21	40	110
Negative	13	7	20	4	7	11	4	12	16	47
Total	32	20	52	23	26	49	23	33	56	157

1 Negative responses

probably due to an exposure of a wider variety of techniques and educational devices. It may be noted that a general increase in all responses probably resulted from better rapport with the experimenters as well as a better understanding of the materials, techniques and equipment.

The principal negative responses, for the control group, concerned the "thermoform" or plastic pages, but these were less prevalent after the subjects got used to them. It is interesting to note that this was not a source of complaint for the experimental group.

The principal negative response for the experimental group concerned the easy nature of the #1 program. The very nature of programmed materials and their low error rate played a part in this reaction.

Some of the subjects were annoyed by the noise the machines made. This was a disturbing factor to some but was corrected somewhat during the course of the summer. It was interesting to find the <u>absence</u> of some responses that were expected. There were also some difficulties in the initial feeding of the tape into the tape readers and Device #2 was not sufficiently reliable to permit uninterrupted use on a day to day basis. It required occasional repairs or adjustment. The positive attitude of S's concerning these devices appeared to overshadow any negative concern they might have had for them.

Experimental subjects had negative feelings toward the structured limitations placed upon them by the programming and equipment in the learning situation. This was intentional on the part of the experimenter as an attempt was made to correct and reduce the negative braille reading factors while emphasizing the positive aspects. This, of course, was of less concern to the beginning braillers and of more concern to those experienced braillers who had acquired what we considered to be "bad habits."

The increase in total number of responses, as well as a continuing three to 1 supporting ratio for this project by the treatment groups seemed to be indicative of lasting approval and interest. There was an observable decrease in the frequency of negative responses on the part of the experimental group, as well as the control group, and this is construed to give low novelty effect.

Many of the experimental subjects were impressed by the immediate reinforcement upon learning the accuracy of their responses. This appeared to be especially true with the automated tachistoscopic educational Device #2.

When the experimental group was asked specifically to rank their preference for the three educational devices (Table XXI), the tape Reader Educational Device #3 was selected by the majority of subjects. Device #2

TABLE XXI

EDUCATION DEVICE AND PROGRAM PREFERENCE ORDER

(EXPERIMENTAL ONLY)

	Level I (N=8)			Level II (N=7)			Combined Total (N=15)		
	First	Second	Third	First	Second	Third	First	Second	Third
Self Paced Educational Device #1	1	1	6	0	2	5	1	3	11
Automated Tachistoscopic Educational Device #2	5	2	1	1	5	1	6	7	2
Tape Reader Educational Device #3	2	5	1	6	0	1	8	5	2

and accompanying program was closely ranked as second choice, and the self-paced Code Oscillator Educational Device #1 a poor third.

Polling the subjects in regard to the last place ranking of Device #1 (with accompanying program) revealed that they enjoyed the programmed materials and felt they profited from their use. However, when asked to make a preference, they chose one of the other two devices and accompanying programs. They indicated their third place ranking did not mean they were opposed to the device or program.

This led to curiosity about what might happen if the control group were exposed to the same devices at the close of the 25 treatment periods. Only three control subjects were available and after 5 practice sessions all selected the tape reader (Device #3) first and Device #2 second. The same three control subjects were able to adjust quickly to the tape reader and were able to exceed their free reading rate in less than one hour of practice time.

There was also concern on whether or not there would be any comprehension loss in using the tape reader. Three controls as well as two high school students in addition to 7 experimental S's were included in the evaluation (Table XXII).

TABLE XXII

COMPARISON OF CONVENTIONAL BOOK FORMAT AND TAPE READER SPEED AND COMPREHENSION SCORES

Level II Braille		Book		Tape Reader	
		Score	Time	Score	Time
Experimental					
	1	16	323	16	260
	2	14	330	18	167
	3	19	899	19	807
	4	4	721	4	691
	5	15	1931	16	1640
	6	15	555	16	599
	7	15	1866	17	1757
Controls[1]					
	8	18	757	19	703
	9	18	587	17	456
	10	4	2527	8	2410
High School Students					
	11	18	317	17	296
	12	13	354	14	220
Total	12	169	11,167	181	10,006
Means		14.08[2]	930.58*	15.08[2]	833.833*

1 Data obtained at conclusion of study.
2 No significant difference.
* Signficant difference at .15 level of confidence favoring tape reader.

A comparison of self-paced conventional book form and tape reader speed and comprehension scores was made after all 12 subjects had a minimum of 10 hours practice on the tape reader. It was apparent (Table XXIII) from our data that post comprehension scores, after using the tape reader, slightly exceeded that obtained from use of conventional book form. This difference was not statistically significant, but a saving of time did favor the use of the tape reader. This difference was significant at the .15 level and indicated a trend worthy of future consideration.

TABLE XXIII

T TEST ANALYSIS BOOK FORMAT (BF) VS TAPE READER (TR)

BF vs TR	df	difference	%	t	p*	Conclusion
Comprehension	11	1.00	7.1	.316	NS	E = C
Time	11	96.75	10.3	1.12	.15	E $\leqq$ C

* t test (Winer page 32)

CHAPTER V

SUMMARY AND CONCLUSIONS

Limitations

The results of the investigation are subject to several limitations:

1. Since the entire available population was consumed in the treatment and control groups, generalizations are based upon inductive rather than statistical inference;
2. Subjects utilized were selected from the adult blind attending the Janesville State School for the Visually Handicapped. Evidence was reported above to indicate the similarity of this sample with the adult blind population of Wisconsin, accordingly, generalizations to the Adult Blind of Wisconsin;
3. The small sample sizes may have limited the efficacy of the statistical analysis;
4. Due to the sparsity of research in this general area, little cross referencing to other studies was possible;

5. The lack of quality of other research on the blind in terms of design, execution, statistical analysis, and reporting made application of other research to the present project difficult.

The sample under study was referred by the Wisconsin Vocational Rehabilitation Department. These adult blind were temporarily placed in a residential setting, and it was difficult to determine what, if any precipital emotional and attitudinal factors may have affected the results. Having these clients available for only six weeks restricted the number of treatment periods to something less than what was desired.

Inadequate or unavailable standardized assessment devices made it necessary to devise our own.

The projection of the theories of this particular project required the researcher to carry out the major responsibility of designing the three devices used. The element of time and budget limitations did not permit perfection of the devices with regard to lack of noise and reliability as we would have liked them. The programs were likewise prepared and pretested, but this phase, too, was limited by problems of time and budget. Initial costs were recognizably high. Modification, simplification and redesign of the educational

devices and programs took place before, during, and after this investigation.

Conclusions

The subjects under study appeared to be a good representative sample of Wisconsin's adult blind population and it was concluded that the results of this investigation might have implications for the total adult blind population.

Treatment groups and levels did not differ significantly on chronological age, sex, I.Q., years of formal education, length of blindness or vocabulary because of random assignment. It is concluded that these factors did not seem to affect the results of the measures of braille reading ability. Subsequently it can be concluded, the inclusion of the three educational devices and programs did produce near significant results, at or near the .05 level, favoring the experimental subjects.

Other results were evident in this investigation:

1. All groups and levels improved in braille reading ability, but the experimental group made more obvious gains.
2. A significant decrease (.01) in braille reading errors occurred within the experimental group.

3. The experimental subjects had a significant decrease (.005) in their number of retracing movements as a result of the treatment under investigation.
4. The experimental group demonstrated a significant decrease (.005) in up-down movements resulting from the experimental treatment.
5. The Tactual Discrimination Test gain scores favored the experimental subjects at the .15 level of significance. When initial test variations were covaried, results were near nonsignificance. However, from inspection of the scores, the trend favored the experimental subjects.
6. The Cell Test results revealed that the experimental group could tactually discriminate single cells correctly at a faster rate than the control group at both levels at the end of the treatment period.
7. Examination by inspection of the directional trends of all measures revealed that the experimental group exceeded the control group on desirable aspects of braille reading.

8. Comparisons of all beginning (non braillers) on all measures, revealed that the experimental treatment group had the same general pattern of desired differences and trends had been found for the experimental subjects having varied initial levels of braille reading ability.

9. The experimental subjects ranked the tape reader best, automated tachistoscopic device and the self-paced auditory reinforcement device in that order of personal preference.

10. Both the control and experimental subjects exceeded their conventional material reading rate when switched to a tape reader after less than one hour of practice.

11. There does not appear to be any significant loss or gain in comprehension between reading either a braille book in conventional format or a braille tape reader, but a saving of time (efficiency) seems to be evident when utilizing the tape.

Educational Implications

The findings of this investigation have several implications for educational practices.

The Tape Display Device is a more efficient and effective means of displaying information in braille than is now provided.

The difficulties of tactual perception make the utilization of high interest, low vocabulary materials desirable. The need for such materials is a result of the slower reading rate and lower perceptual span of the blind as compared with sighted persons. Unlike, the skilled print reader who can perceive a whole word or phrase with a single fixation of the eye and with considerable speed, the blind are restricted and do not share the scope or speed normally emanating from the total word form. Contextual cues being more difficult for the blind must be more pronounced, especially with beginning braille readers.

This project supports the theory that tactual perception is less efficient and effective than vision. Therefore, it becomes more essential that it be developed to a maximal degree of efficacy.

There was little, if any, evidence suggesting that the blind do not translate tactual-kinesthetic impressions into visual imagery. Almost all current perceptual theory is based upon data originating in the visual realm.

It appears from the introduction of programmed materials in a progressive fashion from the easy to the more difficult that the concept of readiness holds for initial tactual presentations.

The fact that certain variables of tactual perception such as retracings and up-down movements are more prevalent with poor readers, suggests that good habits will be acquired if controls are programmed into instructive techniques. The automated tachistoscopic device presents a single braille cell in such a fashion that the subject must perceive pressure stimuli as the cell rises to the finger. There is little time allowed for movement. Horizontal movement is desirable. Repeating, regressing or interrupting of this smooth flow from left to right was controlled by the tape reader device.

This presentation device appears to hold great promise as the means of displaying information in braille and programmed to some storage media. Some experienced braillers were able to read and comprehend braille at a much faster rate from tape than from the conventional book format.

It is necessary, however, to examine the findings of this project with some reservations. Can these and programs be produced economically? Is it a mistake to

encourage self-instruction through self-activity when the activity of the blind has already been more restricted than their sighted peers? What outcomes are desired! Can all necessary teaching strategies be programmed? Will these educational devices and programs serve as supplementary educational techniques with any lasting effectiveness or are they really a novelty effect? In the absence of one of the senses, do special instruction techniques and educational devices become even more essential?

This project has only begun to answer a few of these and similar questions. Researchers and teachers should welcome new ideas and strive to break from traditional bonds in a search for better means of teaching braille. In the light of the results of this investigation it is suggested that specialized teaching methods be developed and effectively utilized in the education of the blind.

Results further imply that a variety of programs, devices and techniques will better equip the teacher to do a more effective job teaching braille. It is easily seen that a teacher restricted to a briefcase can be no more effective than a physician restricted to his little black bag.

Implications for Further Research

In addition to having implications for the education of the blind, the findings of the present investigation suggest the need for further research.

Future research may be based on the outcomes of this project and should involve a longer number of treatment periods. Replications as well as follow up and longitudinal research is desired.

A replication of this research might include larger and more representative samples of blind subjects, therefore, providing a better means of projecting inferences to the general population of the blind.

Because current teaching of the blind is based upon theories developed for the teaching of the sighted, research into the reasonableness of this assumption is necessary.

There also appears to be a need for developing and standardizing a battery of tests for measuring braille skills.

Subsequent research should also attempt to determine what additional specific treatments might counteract the deficit of blindness.

Research into the more effective utilization of the devices developed for this project is required.

The impact of technological developments is just beginning to be felt in the area of braille, and it is therefore important to encourage a blending of professional disciplines as well as the application of recent findings into further investigations.

While this project made little attempt to compare any one device, program or technique with another, there appears to be a need for such comparisons.

Exploration of the motivational effect of high interest materials as well as a multiplicity of presentation media seems desirable. Exploration and research to determine the effectiveness of the use of these devices and programmed materials within the adult blind's home as self-instructional techniques also seems worthy of consideration.

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APPENDICES

APPENDIX A

READING TEST

Part I (Pre Test)

As you read these words, about thirty-six hundred thunderstorms are lashing the earth. In the time required to take a breath, one hundred bolts of lightning are searing the air. It has been like this twenty-four hours a day, winter and summer, year in and year out, since the world began.

Sometimes lightning is playful. For example, there was the time it hit a horse standing in its stall. It knocked off the horse's shoes but left the animal otherwise unhurt. Once it hit a woman who had set her hair with bobby pins. The lightning turned the pins into curling irons. It gave the woman a permanent wave, but did no damage. Lightning once struck a house and raced through the kitchen, touching nothing but a bowl of eggs. It cooked them.

When lightning is not in a playful mood, the results can be tragic. Once it struck an airliner and sent twenty-five passengers to death. It struck a church and killed twenty-seven worshipers. In the United States about five hundred people are killed by lightning every year. Another fifteen hundred are injured. That's more

than twice the number killed by tornadoes, and more than six times the number who perish in floods.

People fear lightning because it is so unpredictable. No one can know for sure what it will do. So men turn to superstitions for an answer. You've probably heard some of the folklore about what to do if a thunderstorm is in the vicinity. The legends say: Lightning never strikes twice in the same place. Don't open any windows, because lightning will follow a draft. Don't use the telephone, because lightning can hit the wire. Don't turn on electrical appliances, because they invite lightning.

Not one of these statements is true. Actually the truth about lightning is more interesting than the folklore.

Part II (Post Test)

Lightning begins under your feet and over your head. Both the earth and the air contain electrical charges. The earth contains positive electrical charges. The lower layers of thunderclouds contain negative charges. Since in nature opposites attract, the positive earth-bound electrical charges are attracted to the negative cloud charges. The two charges try to join each other, but the air prevents their doing so.

The attraction between ground and cloud mounts. Little by little the resistance of the air is broken,

down. As a few charges break through the air barrier, an invisible tunnel is opened up from the cloud to the ground. Then everything happens at once. A spear of electrons called a streamer is hurled toward the earth. Then another drives down, and another. The return stroke--the lightning you see--jumps out of the earth. (It is an optical illusion that lightning comes down from the sky.) The return stroke rips up through the tunnel to meet the charges coming down the cloud. Behind it is a second return stroke. Usually there are six or seven all together. Each travels one hundred thousand times faster than the speed of sound. Each has the power of ten million locomotives.

In its jump from ground to cloud, lightning takes the path of least resistance. It seeks the shortest route. Since tall buildings and trees are closer to the clouds than the earth is, lightning will flow through them. High buildings such as the Empire State Building may be hit several times during one storm. However, their steel frames carry away the force of the charge. Occupants are not aware that the building has been hit.

When outdoors in a storm, your rule of thumb should be to get indoors. Make a beeline for the nearest building. If you can't do that, at least avoid high ground, such as a hilltop. Stay away from trees.

They're probably the favorite outdoor targets for lightning. When a charge passes through a tree, it spills over the nearby ground. It will spill into you if you're standing under the tree.

Lightning is nothing to play around with. It has an awesome record. But unpredictable as it may seem, it follows definite patterns. If you understand them and follow a few simple rules, you will be quite safe. You won't need folklore in a thunderstorm.

	Pre	Post
Average Syllable Length	1.51	1.5
Average Sentence Length	11.5	11.7

From "Lightning," by Alfred Lansing, Collier's, 1955 and Science Research Associates, 1964.

APPENDIX B

TACTUAL DISCRIMINATION TEST DESIGNED BY PATRICK J. FLANIGAN

The Tactual Discrimination Test consisted of figures and shapes made by a Perkins Brailler and a tracing wheel and then reproduced by the "Thermoform Process" on 317 plastic sheets. Seventy five sheets require the testee to tactually discriminate, by multiple choice, similarities and another seventy five differences. Alternation between similarities and differences occurred every 15 frames. The frames were graded from easier discriminations to more difficult. Each subject criterioned after four incorrect responses. The frames were placed in front of the subject and he indicated his decision orally or pointing. The subject was either asked "Which two are alike?" or "Which one is different?" This test was administered on a pre and post basis to Grade I braillers who had no or limited braille reading ability.

APPENDIX C

BRAILLE CELL RECOGNITION TEST

I. LETTERS: All the letters were separated from each other by one blank space.

b g z w c h v a d k f n r e t i l j p s u q m x o y k

f d n a r v e h t c l z j g p b u s x q o y m

II. PUNCTUATION: All punctuation marks were preceded by the full cell (for sign) in order to give the reader a point of reference for the one-dot signs. The cell punctuation signs were separated by two spaces.

capital; comma; apostrophe; period; exclamation; open-quote (or question); closing-quote; parenthesis; capital; period; comma; semicolon; colon; exclamation; closing quote; apostrophe; opening quote; colon; parenthesis; semicolon

III. CONTRACTIONS: All the contractions are single-cell, and were separated by two spaces.

and for of the with of for and the with ch gh sh th wh ed er ou ow ou th gh sh er wh ch th sh ed ow

50 letters
20 punctuation
30 contractions

APPENDIX D

WIDE RANGE TEST

A B O S E R T H

to see cat milk red tree big book was

city eat him animal letter then himself how

deep spell between weather lip block awake

size aboard felt chin tray approve cliff

stalk split huge plot quality escape urge

collapse grieve abuse residence quarantine

contagious glutton exhaust imply image contemporary

theory threshold participate ethics desolate

eliminate triumph tranquillity humidity contemptuous

alcove humiliate conspiracy aeronautic predilection

emphasis municipal rescinded luxurious unanimous

intrigue protuberance audacious benign prevalence

repugnant peculiarity rudimentary pugilist mitosis

bibliography anomaly decisive mosaic deteriorate

spurious irascible expugn coercion discretionary

enigmatic regime centrifugal itinerary abysmal

soliloquize inchoate oligarchy exigencies

mnemonic ingratiating covetousness aborigines

emaciated seismograph pseudonym usurp idiosyncrasy

schism misogyny desuetude exophthalmic succinct

longevity remiges vehemence regicidal evanescence

heinous omniscience conduit

APPENDIX E

MODIFIED LC SCALE

Instructions

This is not a test. I am just trying to find out how people your age think about certain things. I am going to ask you some questions to see how you feel about these things. There are no right or wrong answers to these questions. Some people say "Yes" and some say "No." When I ask the question, if you think your answer should be yes, or mostly yes, say "Yes." If you think the answer should be no, or mostly no, say "No." Remember, different people give different answers, depending how they feel about the question, and there is no right or wrong answer. Just say "Yes" or "No," depending on how _you_ think the question should be answered. If you want me to repeat a question, ask me. Do you understand? All right, listen carefully, and answer "Yes" or "No."

1p. When somebody gets mad at you, do you usually feel there is nothing you can do about it?

2f. Do you really believe a student can be whatever he wants to be?

3f. When people are mean to you, could it be because you did something to make them be mean?

4f. Do you usually make up your mind about something without asking someone first?

5f. Can you do anything about what is going to happen tomorrow?

6f. When people are good to you, is it usually because you did something to make them be good?

7f. Can you ever make other people do things you want them to do?

8f. Do you ever think that people your age can change things that are happening in the world?

9f. If another student was going to hit you, could you do anything about it?

10f. Can a person your age ever have his own way?

11f. When someone is nice to you, is it because you did the right things?

12f. Can you ever try to be friends with another person even if he doesn't want to?

13f. Does it ever help any to think about what you will be when you get out?

14f. When someone gets mad at you, can you usually do something to make him your friend again?

15f. Can people your age ever have anything to say about where they are going to live?

16f. When you get in an argument, is it sometimes your fault?

17p. When nice things happen to you, is it only because of good luck?

18p. Do you often feel you get punished when you don't deserve it?

19f. Will people usually do things for you if you ask them to?

20f. Do you believe a kid can usually be whatever he wants to be when he grows up?

21p. When bad things happen to you, is it usually someone else's fault?

22f. Can you ever know for sure why some people do certain things?

APPENDIX F

Device and program for teaching tactual discrimination.

APPENDIX G

PROGRAMMED LEARNING

When one speaks of "programmed learning" reference is made to the way in which subject matter is broken down into sequential steps, referred to as a "frame," beginning with relatively simple concepts and systematically proceeding to more difficult principles. Basically the principles of programming have developed from a blending of various theories of learning.

Through a step by step progression, a student gains an understanding of the more complex aspects of a subject by dealing always with increments he can handle. Each step in a program elicits an answer to a question requiring either an "overt" or "covert" response related to what is being studied. By these frequent responses there exists some interaction between the student and the subject matter if maximum learning is to take place.

The advancement from step to step can be controlled by the subject, teacher or machine and is referred to as "pacing."

Two basic styles of programming, with many variations, are the "linear," which presents information in a structured sequence regardless of response accuracy and the "branching" technique which presents information

in more than one sequence and uses response accuracy to determine the sequence employed.

As a student makes a response, he can compare his answer with the one provided in the program. Thus he knows immediately whether he is right or wrong. A well constructed program makes it unlikely the student will be wrong. A high rate of correct responses is desirous and is referred to as "positive reinforcement." Hopefully, most learning theorists feel it should occur frequently and will base their opinion upon scientific knowledge of how learning takes place. They also support the idea that learning the answer immediately is an essential ingredient of learning and is referred to as "immediate feedback."

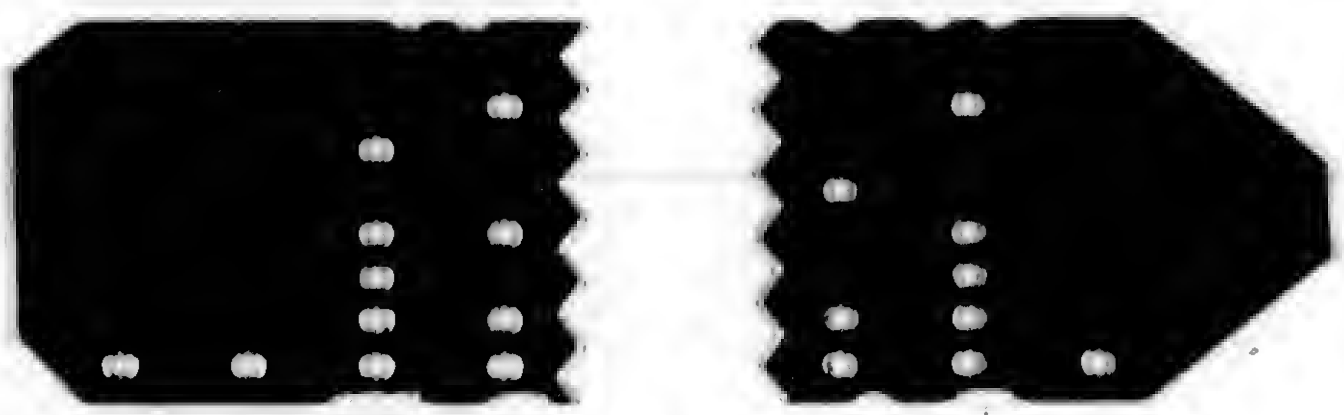
Small increments of information arranged in a logical sequence providing maximum learning, active participation, low error rate, immediate feedback, and optimal pacing are often referred to as the basic ingredients of programmed instruction.

Programmed materials make it possible for the slower learner to proceed at his own rate. This gives him as much chance to learn as the fast student although it may take him a little longer. Programmed materials free the teacher for individualized instruction whenever

it is needed, and for enrichment of the entire curriculum putting an end to the lock step process that has plagued the traditional classroom over the years.

APPENDIX H

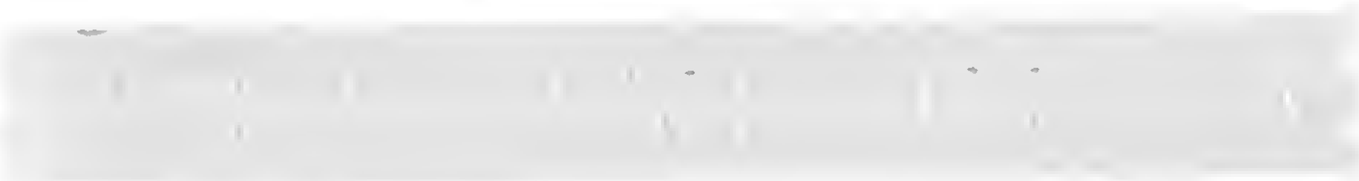
Device designed to increase accuracy and speed of recognition of braille symbols.



Sample Program

APPENDIX I

Device for increasing braille reading rate.



Sample Program tape

APPENDIX J

RAW DATA CODE

<u>Variables</u>

1. Subject
2. Chronological Age
3. Intelligence Quotient
4. Sex 1=M 2=F
5. Education
6. Diabetes 1=Yes 2=No
7. Degree of Blindness 1=LB 2=TB
8. Age of Onset
9. Motivation 1=Good 2=Fair 3=Poor
10. Wide Range
11. Vocabulary
12. Fingers 1=RI 2=LI 3=Others
13. Internal Locus Control
14. Alphabet
15. Punctuation
16. Contractions
17. Total Cell Score
18. Cell Test Time (Seconds)
19. Previous Conventional Braille Instruction 1=Yes 2=No

*20. Pre TDT
*21. TDT Gain
*22. Pre Reading Speed
*23. Post Reading Speed
*24. Pre Error
*25. Error Gain
*26. Retrace Pre
*27. Retrace Gain
*28. Up Down Pre
*29. Up Down Gain

30. Educational Device Preference Order
31. Future Participation 1=Yes 2=Maybe 3=No
32. Previous Summer Schools Attended
33. Pre Error M II
34. Error Gain M II
35. Time Gain M II

*Constant added to remove negative numbers.

RAW DATA

1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	54	117	1	12	2	1	45	1	118	66	1	6	44
2	68	135	2	12	2	1	57	1	99	68	1	5	35
3	46	78	2	6	2	1	40	1	61	16	1	12	21
4	31	80	1	8	1	1	25	2	64	26	3	10	24
5	41	99	2	12	2	1	27	1	103	29	1	8	50
6	40	128	1	17	1	1	35	1	84	64	2	3	40
7	42	115	2	13	2	1	32	1	79	57	1	5	44
8	67	96	1	8	2	1	60	2	54	28	1	9	44
9	23	133	1	15	1	1	23	1	109	72	1	6	49
10	22	108	1	12	2	2	1	1	84	63	1	6	49
11	46	128	1	12	2	2	1	1	118	66	2	6	50
12	43	88	2	11	1	1	1	1	59	28	1	9	50
13	47	122	1	9	2	1	1	1	108	69	1	5	47
14	63	119	1	12	2	1	58	1	98	63	1	6	40
15	33	115	1	12	2	1	20	1	110	55	1	4	47
16	41	118	2	8	1	1	30	1	106	52	1	6	39
17	65	139	2	9	2	1	60	1	109	75	1	2	36
18	58	94	2	5	2	1	55	1	64	30	1	9	41
19	43	91	2	12	2	1	39	2	95	35	2	6	17
20	22	106	1	10	2	1	21	1	61	51	1	5	42
21	32	89	2	8	2	1	1	1	43	22	1	5	40
22	60	120	1	16	2	1	54	1	112	66	1	7	43
23	46	132	2	12	2	1	42	1	112	75	1	6	47
24	69	124	2	14	1	1	65	2	90	72	1	8	41
25	53	111	2	12	2	1	40	1	111	62	1	1	47
26	60	80	2	8	2	2	2	1	58	23	1	8	42
27	19	104	2	12	2	2	1	1	107	54	2	6	50
28	30	96	2	12	2	1	1	1	73	46	1	9	50
29	67	108	2	8	2	1	1	1	104	58	2	4	49
30	49	91	2	12	2	1	40	1	108	46	1	7	50
31	66	105	2	10	2	1	53	2	91	53	1	7	40

RAW DATA (Continued)

15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
10	23	77	1050	1	109	55	20	34		No Pre Test Scores--Non Braillers				
2	2	39	1770	1	63	60	20	24						
0	0	21	740	1	71	69	20	20						
4	1	29	1926	1	120	57	20	22						
17	26	93	721	1	184	23	28	26	14	14	60	54	75	37
17	17	74	540	1	117	60	28	22	19	9	59	55	53	31
0	0	44	213	2	184	34	30	26	25	12	73	61	78	32
1	6	51	542	2	129	55	28	16	22	12	99	48	80	28
19	28	96	475	1	102	71	88	20	13	9	70	52	74	22
19	29	97	111	2	Tactual Discrimination Test Given Only To Level I		395	1	16	10	71	52	33	33
20	29	99	226	1			164	94	16	14	56	61	35	47
10	26	86	1205	2			34	10	18	20	58	60	65	56
8	28	83	435	2			112	2	16	10	75	48	47	36
15	22	77	743	2			40	6	25	8	71	54	61	56
18	27	92	203	1			30	28	20	10	86	57	78	31
12	22	73	510	1			38	17	18	16	66	51	45	36
1	1	38	830	1	103	54	20	24		No Pre Test Scores--Non Braillers				
0	0	41	724	1	50	86	20	24						
0	0	17	550	2	81	63	20	21						
0	18	60	1265	1	120	77	20	26						
0	25	65	850	1	63	48	20	31						
15	26	84	710	1	76	117	29	25	25	2	114	0	64	14
16	26	89	616	1	109	85	31	31	16	12	71	38	74	15
6	22	69	815	1	88	56	28	26	21	7	82	28	73	15
15	29	91	243	2			215	95	16	11	110	27	68	26
4	16	62	423	1	TDT		215	29	30	0	70	29	53	20
12	29	91	104	2	Not		413	108	18	8	105	18	51	20
19	29	98	235	2	Given		392	58	15	11	67	45	36	10
18	29	96	210	2	(See		252	89	16	13	73	38	35	31
18	25	93	525	1	Above)		46	31	22	7	83	34	71	19
9	20	69	727	1			67	14	25	6	76	45	96	0

RAW DATA (Concluded)

30	31	32	33	34	*	35
Controls Not Able to Select Machine Choice	1	0	Controls Not Exposed to Device #2			
	1	0				
	1	0				
	2	1				
	1	0				
	1	4				
	1	2				
	2	3				
	1	0				
	1	0				
	1	3				
	2	2				
	1	1				
	1	3				
	1	1				
	1	1				
231	1	0	52	8	100	33
231	1	2	138	5	100	0
123	1	0	130	21	100	0
231	1	0	77	44	100	50
231	1	1	107	39	100	25
231	1	4	45	20	100	33
321	1	2	61	11	100	50
213	2	0	57	19	100	0
231	1	2	24	3	100	33
321	1	0	52	13	100	0
312	1	0	23	12	100	50
321	1	4	12	8	100	66
321	1	7	21	3	100	17
213	1	2	42	19	100	50
321	1	5	60	15	100	25

*Same basal time for all experimental subjects

TITLE OF THESIS Effectiveness of Programmed Learning in Braille Instruction for the Adult Blind

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